MAY • 1956

PETROLEUM REFINER

REFINING | PETROCHEMICALS | NATURAL GASOLINE

Gulf Publishing Co

API ISSUE

Computers Take Over . . . . Page 138

New Technique in Cracking . . Page 166

How RP-500 Looks . . . . Page 151

When you check these factors . . .

to SERVE the NATURAL GASOLINE INDUSTRY

You *Naturally* Look to . . .

WARREN

PETROLEUM CORPORATION

TULSA, OKLAHOMA • Cable Addresses: STAVOLENE, WARREN

EXPORT TERMINALS: CORPUS CHRISTI, PORT ARTHUR, BAYTOWN, TEXAS CITY AND WARRENGAS, (HOUSTON) TEXAS; SAN PEDRO, CALIF.

TECHNICAL DATA

Base Stocks to Finished Products
in One Easy Step!

★ **MAXIMUM FLEXIBILITY**

An infinite number of adjustments from 90% residual fuel and 10% distillate to 50% residual and 50% distillate.

★ **FAIL-SAFE OPERATION**

Blender automatically cuts off flow of fuel to ship or other transportation means should either base stock stream fail.

★ **MOBILE OR SKID-MOUNTED**

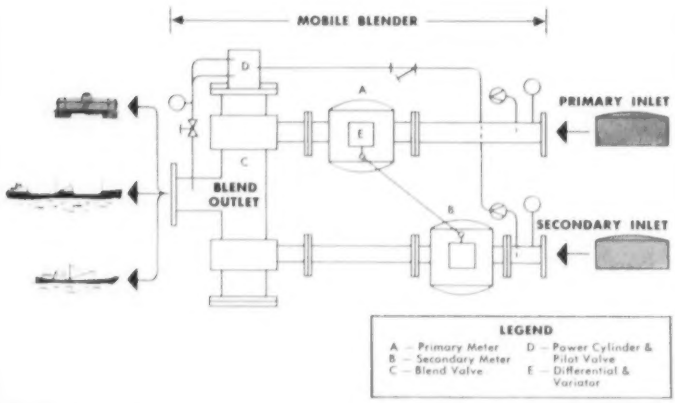
Fully mobile for "on-the-spot" blending at dockside fueling stations or terminals. Skid-mounted model also available for more permanent installations.

PROPORTIONEERS Mobile Fuel Blender

★ **SELF-OPERATED**

No external source of control power is required as blend valve is hydraulically positioned by pressure differential. Flow responsive to automatically follow demand for blended product while maintaining correct ratio.

"THE BEST COSTS LESS"



MOBILE BLENDER OFFERS INCREASED FLEXIBILITY AND ECONOMY!!

THE PROBLEM:

The increasing demand for special blends of light and heavy distillates, including residual fuel oils, presents many problems to terminal operators. It is not economically feasible to maintain an inventory of finished blends to meet the varying requirements of present day marketing . . . nor is it always possible to provide bunker fuels, special diesel blends, and heating oils with only a few hours advance notice. We were asked to solve this problem:

THE ANSWER:

PROPORTIONEERS new Mobile Two-Component Blender eliminates the need for multiple tank systems at loading terminals . . . and permits continuous, automatic, "on-the-spot" blending of ready-to-ship distillates . . . directly from base stock storage tanks to ship, barge, or tank car. In addition to reducing the number of tanks necessary to make such a facility fully flexible and conserving valuable land area otherwise lost to tankage, this Blender eliminates the extra step required to move fuels from base stock storage to blending tanks before transfer to carriers.

APPLICATIONS:

- Fuel Blending
- Diesel Blending
- Jet Fuel Blending
- Turbine Engine Fuel Blending
- Heating Oils Blending (For truck loading, request Bulletin 2070 for complete data on TC Blender.)

Write for Bulletin 2065 to **PROPORTIONEERS, INC.**
412 Harris Ave., Providence 1, R. I. . . . division of

B-I-F INDUSTRIES
PROVIDENCE, RHODE ISLAND

B-I-F METERS FEEDERS CONTROLS

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • OMEGA MACHINE CO. • BUILDERS-PROVIDENCE, INC.

Volume 35, No. 5 May, 1956

PETROLEUM REFINER
REFINING | PETROCHEMICALS | NATURAL GASOLINE

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A Quick Look

at This Issue

These handy digests permit checking ✓ those articles you want to read first.

API SECTION

☐ **Computers Take Over** . . . Computers demonstrate their success in improved refinery operations. This refinery has worked its way up through the various sizes of computers. For many valuable tips on getting started in computer activities, turn to Page 138.

☐ **Use Computers for Refining Problems** . . . There are so many ways to make petroleum products that the best combination of processes is difficult to determine. Here's the way one company uses a high-speed electronic computer to obtain a complete refinery balance. Read how process engineers are liberated from tedious desk computations. Turn to Page 139.

☐ **Equilibrium for C_6's and Hydrogen** . . . A digital computer has been used to establish the equilibrium compositions of a system containing C_6 hydrocarbons and hydrogen. You will find the results are of great help in reforming, isomerization and dehydrogenation. Turn to Page 141.

☐ **Design for Minimum Corrosion** . . . The steps described in this article are a must for reformer design. The basis for metallurgical selection are discussed and the methods for continuous corrosion control revealed. Before you plan your next reformer, review this article carefully . . . Turn to Page 146.

☐ **A Contractor's Reaction to RP-500** . . . Arbitrarily determining hazardous area limits of a refinery process unit can prove expensive and dangerous. By following RP-500, a uniform approach resulting in a coordinated installation based on sound principles and logical conclusions will result. For complete effects of this standard . . . Turn to Page 151.

☐ **Preventive Maintenance in Action** . . . What is the "ideal" preventive maintenance program? Such a program is being administered successfully at Tide Water's Avon refinery. For complete details, turn to Page 154.

→ Now Turn the Page →

A Quick Look at This Issue . . .

☐ **How to Measure Maintenance Results** . . . Here is the most effective yardstick for measuring maintenance results. Maintenance costs as percentage of replacement value for various types of process units are given. Learn how to apply these ratios in your refinery . . . Turn to **Page 159.**

☐ **Cat Cracking Now in Two Stages** . . . Conventional catalytic cracking units operate at a compromise between overcracking some portions of the feed and undercracking other portions. By operating two cracking zones, a wide operation flexibility is obtained for shifting from maximum gasoline to maximum intermediates production. For both pilot-plant and commercial data on this new technique . . . Turn to **Page 166.**

☐ **Ultraform to Get 100 Octane, Clear** . . . The largest Ultraformer built to date has been operated for over a year, and the difficulties encountered in earlier operations have been overcome. See **Page 171.**

☐ **Research Committee Reports** . . . Here is the condensed version of this committee's report on its ten research projects. Conclusions reached from programs already completed as well as advance reports on projects now being completed are given. **Page 178.**

☐ **How New Is the Disposal Problem?** . . . Ever wonder how long there has been a disposal problem? When did it start and what has been done to bring it under control? This history of the committee activity and its accomplishments brings you up-to-date. Turn to **Page 181.**

☐ **Trace Analysis Catches Up** . . . From arsenic to zinc, petroleum chemists have improved methods to determine trace elements, as you will see in these abstracts of papers presented at API. We've also covered the sessions on Fuels & Lubricants, Training and Instrumentation. Turn to **Page 184.**

☐ **Holding High-Pressure Joints** . . . Here is an interesting summary of the high-pressure joints in general use . . . and how they tick. You can get some new ideas and a better understanding of costs. Turn to **Page 189.**

☐ **How Texas Gas Recovers More LPG** . . . This plant had some idle air compressors. By putting them to work in an iso-butane refrigeration system, recovery of LPG was increased. Read how this was done with a small capital expenditure . . . Turn to **Page 194.**

☐ **Esso Installs 34.5KV Station Switchgear** . . . Here's how the Baltimore refinery expansion power needs were fulfilled. It's one of the first installations of high voltage central station type switchgear in a refinery. Turn to **Page 196.**

☐ **Take Stock of Radioactivity** . . . Here is a timely, comprehensive review of the present and future uses of radioisotopes in refining. These applications may help improve your refinery operations. Turn to **Page 201.**

☐ **How Automation Affects Maintenance Cost** . . . Here are money-making tips for any operation planning to use automation. For valuable information on the five ways automation can affect maintenance cost—and factors to be considered in holding these costs at their just level, turn to **Page 213.**

☐ **Unifining-Platforming in One Unit** . . . Here is a description of one of the first units to have a Unifining unit physically combined with a Platforming unit. Inspection data are given for typical charge and products. Turn to **Page 216.**

☐ **The Dollar Value of Human Relations** . . . Here is a five-point human relations program designed to raise profits by lowering maintenance costs. Check this proved system of improving personnel relations. Turn to **Page 218.**

☐ **A Better Ash Determination** . . . There is evidence that some ash is lost during the free-burning step of most ash determinations. This article proposes a method which recovers the ash normally lost by other methods. See **Page 220.**

☐ **Determine Heat Transfer Coefficients** . . . When information on thermal conductivity and specific heat is lacking, you may use this easy and satisfactory method to estimate the film coefficient of heat transfer to hydrocarbon liquids inside tubes. **Page 227.**

☐ **What Will Gasoline Be Like in 1960?** . . . U. S. gasolines probably will have average octane ratings of 93 for regular and 100 for premium. This well-known research director also looks for front-end volatility to be lighter and tail-end heavier. Past trends back up his extrapolations . . . Turn to **Page 230.**

☐ **Lube Oil Additives - - - A Big Business!** Yes indeed! Did you know that almost 600 million pounds will be used in 1956? This will amount to over $140 million for the additive manufacturers. Mighty big amount of money for this industry which most of us thought was an insignificant one. Take a look at this surprising information on **Page 235.**

☐ **Estimate Gasoline Yields from Crudes** . . . Here is a simple empherical equation to help you estimate gasoline yields from crude. This method is a time-saver because only the minimum routine crude test data is required . . . **Page 236.**

☐ **"These Get the Job Done for Me"** . . . A survey of supervisors shows that every individual has his own pet method of leadership. Here, in brief form, are 25 of those leadership secrets. Look them over. You may find some—or many—will fit into your operation. Turn to **Page 136.**

Other Management articles start on Page 268

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SUBSCRIPTIONS

R. M. de Sombre, Circulation Manager, P. O. Box 2608, Houston 1, Texas, U.S.A. Single copies 50 cents (except special issues) for U. S. and Canada; $1 for all other countries. Subscription rates—U. S. and Canada $2 a year; Latin America and overseas $5 a year. Subscriptions restricted to those engaged in refining, natural gasoline or petrochemical industries or service and supply company personnel connected thereto. PETROLEUM REFINER, published on the 16th of this month, entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act March 3, 1879.

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Specialized Oil Publication of
THE GULF PUBLISHING COMPANY
Box 2608, Houston (1), Texas

PETROLEUM REFINER and The REFINERY CATALOG for the refining natural gasoline-petrochemical industry

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Petroleum Refiner is Indexed by Industrial Arts Index, Chemical Abstracts and by Engineering Index, Inc. Microfilm copies available through University Microfilms, An Arbor, Michigan.

Not Enough Fanfare

DID YOU NOTICE the series on automatic control that was started in last month's issue? We are beginning to wonder whether our modesty prevented this series from getting its fair share of attention. The title of the series is "Automation Today," the author, Capt. Theodore J. Williams.

Capt. Williams intends to give a full treatment of this subject before he is finished. The present group of articles demonstrates the use of automatic control for individual units and considers some of the problems of complete refinery automation.

If you missed the first part of this series, wait no longer in getting started on the second part, Page 205 of this issue. Capt. Williams now is getting into the real meat of the subject.

How Big Is Biggest?

RECENTLY A chemical magazine declared that the chemical industry was the largest manufacturing industry. We suggest that the editor take another look at certain figures:

The entire chemical and allied industry spent $1 billion in 1955 for capital expenditures (this includes petrochemicals) while the entire petroleum industry spent $2.756 billion (this does NOT include petrochemicals). No other single manufacturing industry spent within 53 percent as much as the petroleum group, according to U. S. Department of Commerce figures. And capital investment is about the only index of growth of an industry.

Of interest is this table from a U. S. Treasury report:

Cost of Plant and Equipment Per Working Man

	(Actual Dollars)
1. Petroleum	$81,402
2. Chemical	19,194
3. Paper	9,727
Average of all manufacturing industry	**9,407**
Rubber	9,028
Textiles	4,455

Note that petroleum industry is approximately nine times greater than the average of all manufacturing industry and is more than four times greater than the second industry, chemical.

Thanks A Million

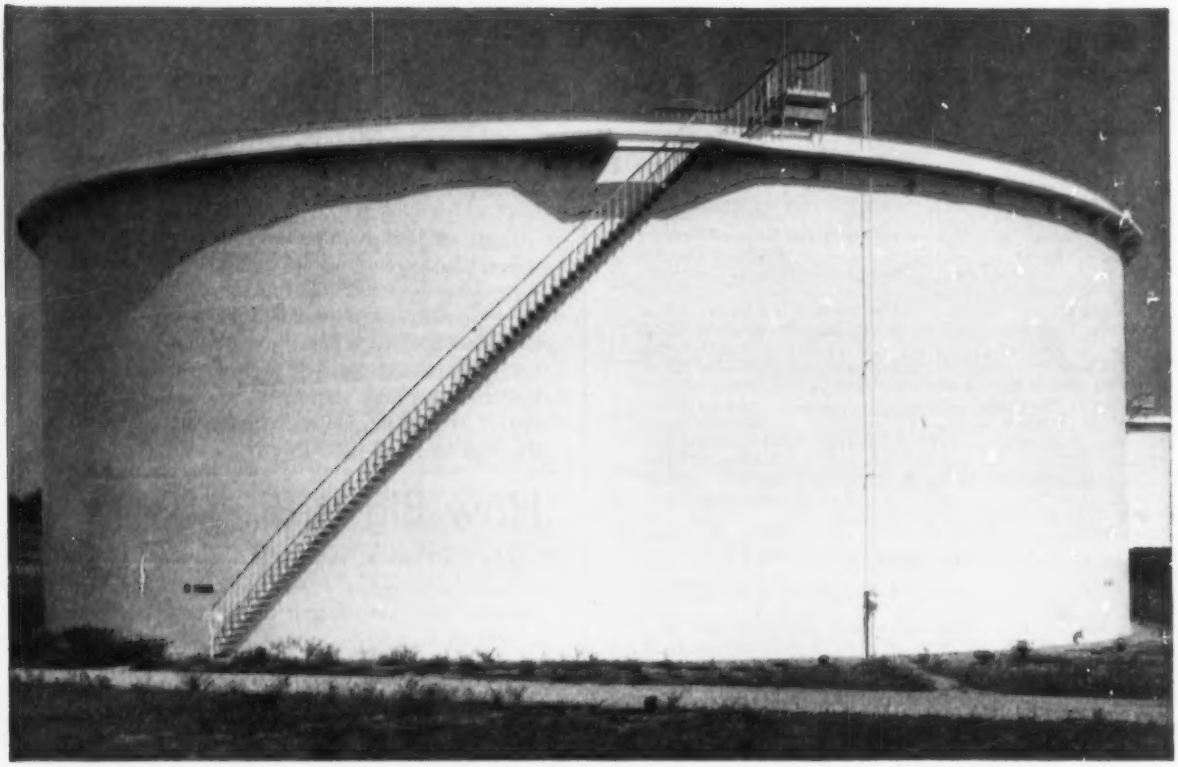
WHENEVER YOU respond to one of our articles—one that has been of particular help to you—it sends our editorial spirits soaring. A case in point is our March survey, "Employing the College Graduate."

The many complimentary letters on this one article more than justified our efforts in rounding up the data. Your many requests for reprints—50 for Stanolind, Standard of California, 20 for U. S. Rubber, 15 for Texas Company, 15 for Carter Oil, 12 for Gulf Oil, 8 for Sunray, etc.—were sincerely appreciated.

And then, as shown in The Mail Box, Page 122, the colleges thought it a real service.

Thanks a million.

P. S.: There are still some reprints left. Would you like some?



the GRAVER "Double-Deck"—our costliest... and often least expensive... floating roof design

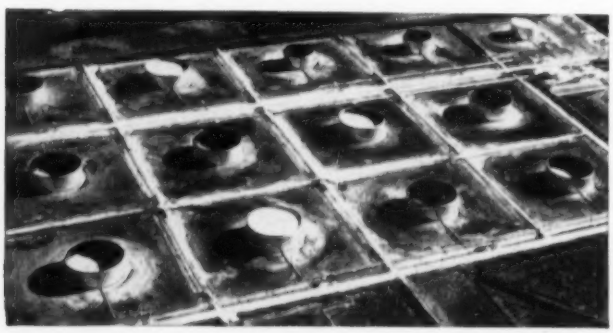
While the Graver Double-Deck Floating Roof Tank is the costliest of our three "floaters," it often proves least expensive in the long run.

Its unusual strength and structural stability make it appropriate wherever storage problems are encountered. The double-deck roof, consisting of top and bottom deck plate, is divided into liquid-tight compartments. Thus it is practically unsinkable. With the Graver Double-Deck Floating Roof Tank maintenance costs are held to a minimum.

Other popular Graver designs include the Center-Weighted Floating Roof Tank which is unusually stable. We offer also a pan-type floating roof...an economical design suitable to southern climates where snow and ice present no hazard.

Whatever your storage needs it will pay you to contact Graver. Consultation costs you nothing, and competent Conservation Engineers are ready to serve you.

GRAVER ... *a conservation design to fit every need*



GRAVER FLOATING ROOF TANKS, four of which were built for the TEXAS PIPE LINE COMPANY at Port Arthur, Texas.

GRAVER TANK & MFG. CO., INC.

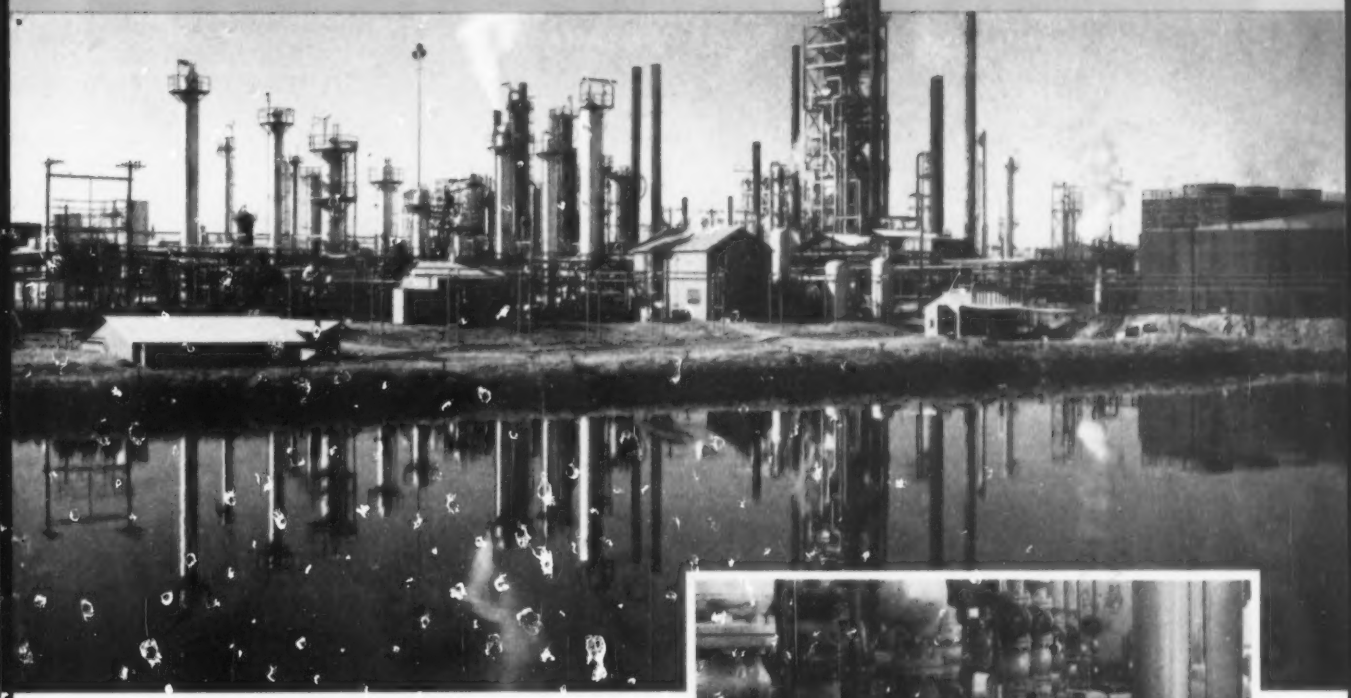
East Chicago, Indiana

CHICAGO • NEW YORK • PHILADEPHIA • EDGE MOOR, DEL. • PITTSBURGH • DETROIT • TULSA • SAND SPRINGS, OKLA. • HOUSTON • CASPER, WYO. • LOS ANGELES • FONTANA, CAL. • SAN FRANCISCO

All Material Procurement by

"OILWELL"

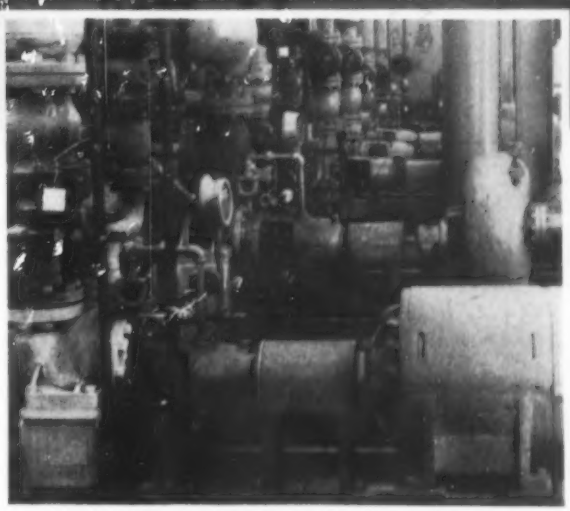
and it arrived on schedule!



NEW CONSTRUCTION involves problems of procurement and expediting, as well as design and erection. But American Liberty Oil Company, Mt. Pleasant, Texas, avoided all this when they modernized their 5,000 b/d thermal cracking facilities and added a new 6,000 b/d catalytic cracking unit.

How? By selecting "Oilwell" to procure the materials and equipment involved in the construction of this project . . . thus centralizing all the details in one reliable source.

IF YOU . . . are about to undertake a construction project, bring your procurement and supply problems to "Oilwell." Learn for yourself the many advantages of shifting logistic responsibilities to a long-established, fully-integrated organization that specializes in supplying the Petroleum Industry.



A few of the 20 Wilson-Snyder Type ES Centrifugal Process Pumps which handle the various combinations of capacities, differential heads, specific gravities and temperatures involved in this installation. Wide interchangeability of parts results in minimum inventory requirements.

OIL WELL SUPPLY
DIVISION UNITED STATES STEEL CORPORATION

Executive Offices—**DALLAS, TEXAS**

with Refinery Equipment Specialists at

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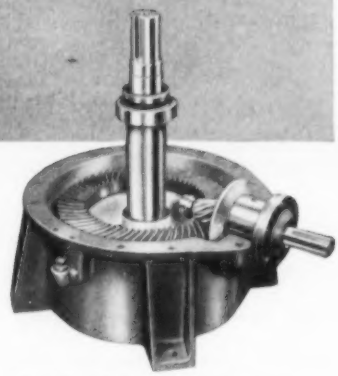
USS TRADE MARK

"OILWELL" TRADE MARK

UNITED STATES STEEL

this GAS COOLER depends on Phillie Gear Cooling Tower Drives



The installation shown above is at the Warren Petroleum Corporation's Processing Plant, at New Antioch, Oklahoma, and is but one of many such satisfactory installations throughout the petroleum, chemical and air conditioning industries.

The growing use of larger fans in cooling tower service brought the need for a drive that would best meet heavier load conditions. The Philadelphia Spiral Bevel Cooling Tower Drive provides a highly rugged and durable drive to satisfactorily handle these higher fan loads. Hundreds of applications have proved that Philadelphia Cooling Tower Drives will out-perform and out-last any other type of unit.

Write for our new catalog CT-53 illustrating all types of Cooling Tower gear drives and their applications.

check these features of our Spiral-Bevel Unit

- Maximum Efficiency . . . 97%-98% with minimum heat loss.
- Precision generated Spiral-Bevel Gears, case hardened for long service life.
- Heavy duty housing construction.
- High dome permits mounting fan directly on unit, with ample clearance below fan blades.
- Oversize bearings insure trouble-free operation. Positive splash lubrication provides oil both for bearings and gears.
- Rugged . . . dependable . . . economical Reducer meets all AGMA standards.

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ERIE AVE. & G STREET, PHILADELPHIA 34, PENNA.
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INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID AGITATORS • FLEXIBLE COUPLINGS
Virginia Gear & Machine Corp. • Lynchburg, Va.

For more data on advertised products, use Readers' Service Cards, last page.

End uncertainty in getting the longest tube life per dollar:

... *ask the experts!*

WHATEVER your high-temperature steel problems—heat, pressure, corrosion, oxidation—there's always one tube steel among the Timken Company's 24 different high-temperature analyses that will do the best job. One that will give you the maximum service per dollar and cost per year of required service—the best life/cost ratio.

To find this *one*, right analysis, *ask the experts!*—the metallurgists of The Timken Roller Bearing Company.

These experts are recognized authorities on high-temperature steels, have been for over twenty years. And they're ready to put their experience to work for you. They'll study your particular requirements, recommend the one tube steel to most satisfactorily and economically meet them. Result: you get the longest tube life per dollar.

And you can be assured of uniform high quality in the Timken® steel you get. For the Timken Company controls and guards steel quality from the furnace to final inspection.

Call on Timken Company metallurgists for understanding help in solving your tube steel problems. End uncertainty. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

SICROMO-7

Suggested as a subsitute for steels of the 5.0 per cent chromium type for applications which require increased resistance to corrosion by hot petroleum products.

23 TIMKEN® STEELS FOR HIGH TEMPERATURE SERVICE

Carbon	Sicromo 2	Sicromo 5S	16-13-3
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	25-20
DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-12
Silmo	Sicromo 3	Sicromo 9M	35-15*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti	18-8 Cb	

*Not available as seamless tubing at the present time.

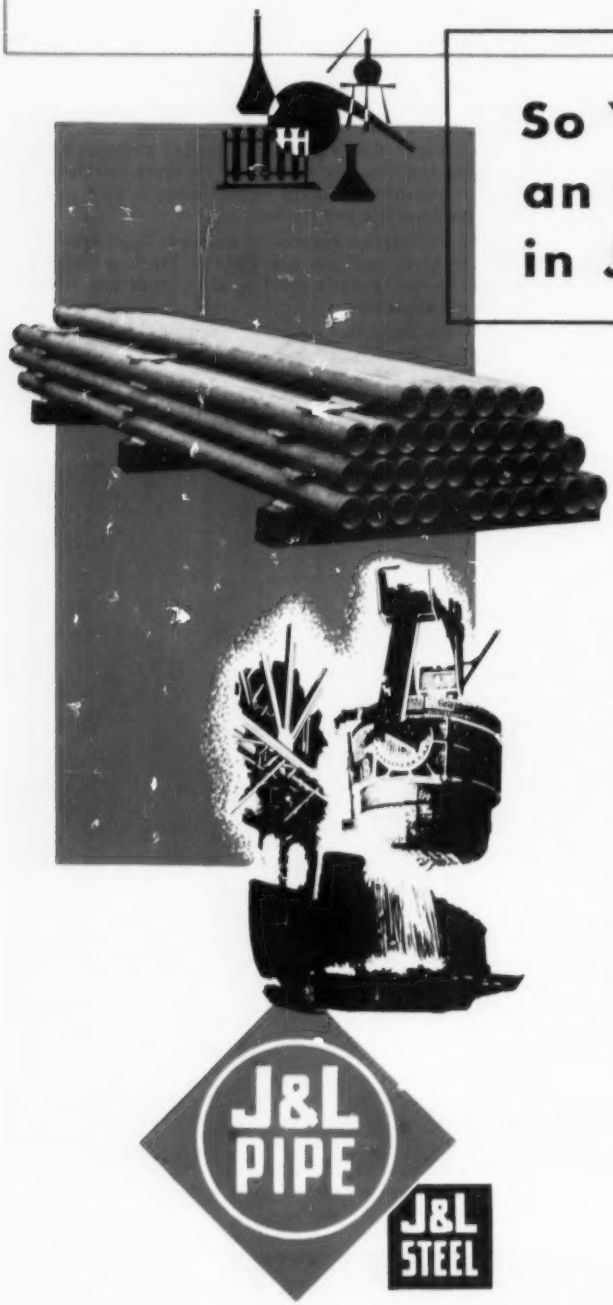
General view of the Timken Company metallographic laboratory where many analyses of steels are viewed under high-power microscopes.

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

For more data on advertised products, use Readers' Service Cards, last page.

Scarcity Accents the Importance of Quality . . .



So You Have an Important Stake in J&L Research

Every man who buys or uses or is interested in the use of A.P.I. Tubular Products can observe the results of J&L research.

It is reflected in the adaptability and useful life expectancy of every length of J&L pipe, seamless or welded.

It is reflected in the excellence of the technical services of J&L Supply Men actively and enthusiastically interested in helping you get maximum dividends from your pipe investments.

J&L PIPE

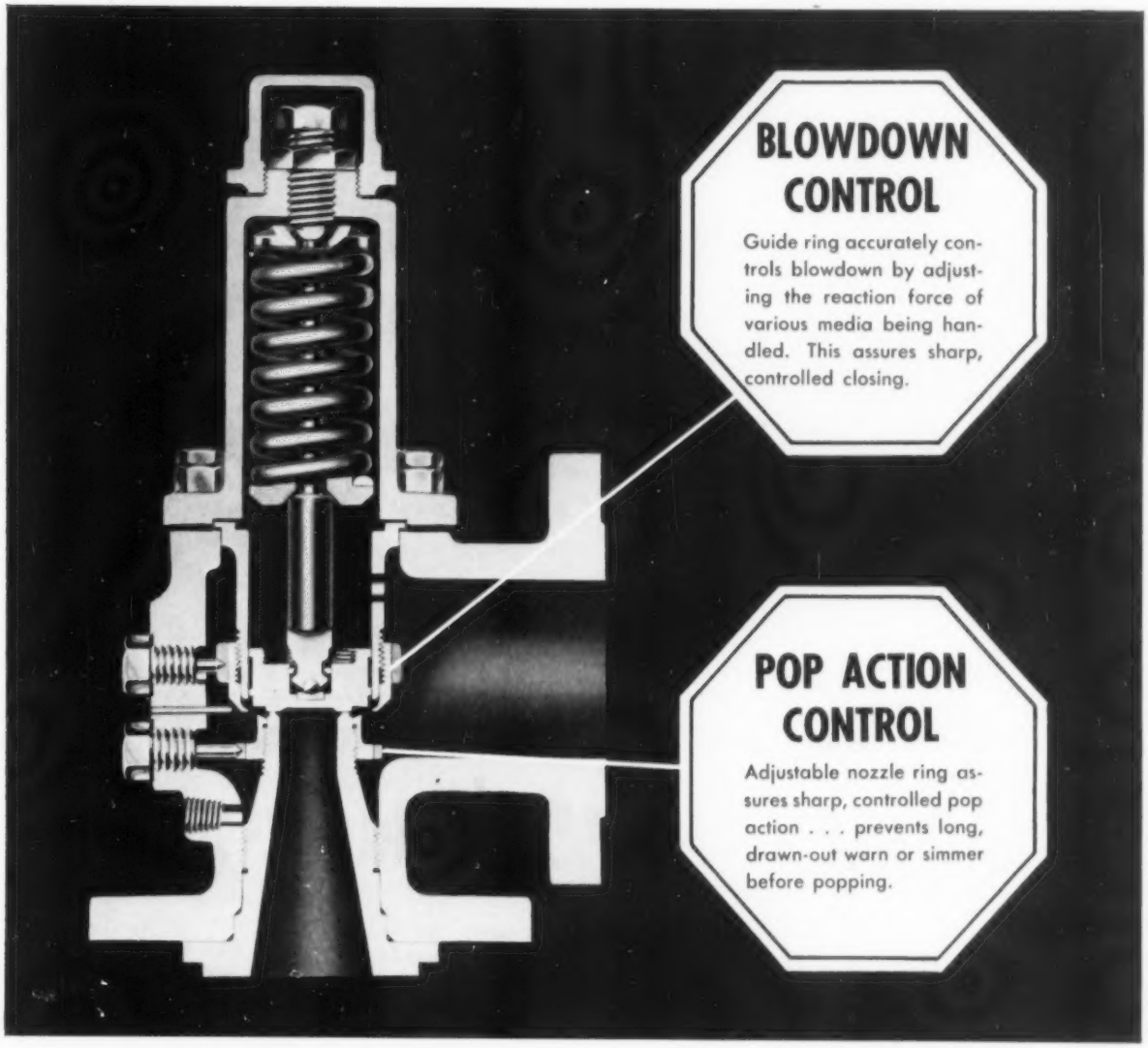
J&L STEEL

Jones & Laughlin

SUPPLY DIVISION – Tulsa

SERVING THE UNITED STATES AND CANADA

3-1


BLOWDOWN CONTROL
Guide ring accurately controls blowdown by adjusting the reaction force of various media being handled. This assures sharp, controlled closing.
POP ACTION CONTROL
Adjustable nozzle ring assures sharp, controlled pop action . . . prevents long, drawn-out warn or simmer before popping.

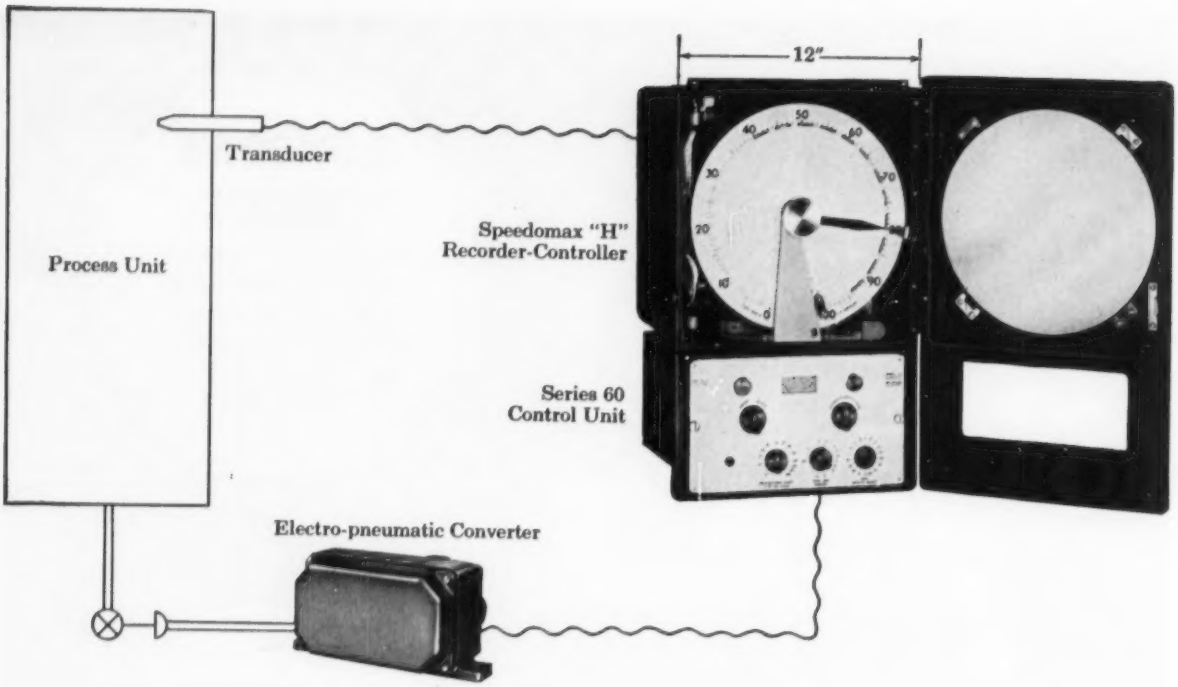
Look for these Signs of Safety

The performance built into every Crosby Nozzle Type Safety-Relief Valve results from basically sound engineering plus materials and workmanship of the highest quality. Crosby Valves meet the need for maximum operating dependability and minimum downtime and maintenance. Because they incorporate generous safety factors, these valves stay on the job for years. Write for Bulletin describing the complete line of Crosby Relief Valves—or ask for our quote on your valve requirements.

CROSBY STEAM GAGE & VALVE COMPANY
43 KENDRICK STREET, WRENTHAM, MASS.

Crosby
KEEPS PRESSURE ON THE SAFE SIDE

For more data on advertised products, use Readers' Service Cards, last page.



L&N'S NEW C.A.T. ELECTRO-PNEUMATIC CONTROL

gives you these advantages:

• FAST ELECTRICAL RESPONSE in measurement, control, transmission.

• SIMPLICITY, LOW COST, ADAPTABILITY and the special safety of pneumatic operation.

• EASY INSTALLATION with only 1 pair of leadwires from the control unit to the converter mounted near the process; then short air lines from converter to valve.

L&N's C. A. T. (Current-adjusting type) Control combines the advantages of pneumatic valve operation with the flexibility and fast response of an electrical control system. The electrical signal produced by a change in the process variable passes from transducer, to Speedomax recorder, to L&N Control Unit. Here, the properly tuned combination of proportional, rate, and reset actions produces a control current which is fed to the Electro-pneumatic Converter. The Converter matches the control characteristics of the current output with an air pressure which operates the pneumatic valve.

The L&N Control Unit and all of its replacement parts are "plug-in" type for fast, easy servicing. The Unit's proportional band is adjustable from 0 to 500% of recorder range, rate time is continuously adjustable from 0 to 8 minutes, and reset action runs from 0 to 100 repeats per minute.

The force-balance type Electro-pneumatic Converter is ideal for installation directly on the process unit. It can be mounted anywhere, in any position; is vibration-resistant and weather-proof. Its minute (5 milliamp) current and continuous air purge provide a wide safety margin for operation in hazardous areas. If power fails or the control unit is removed, the control valve is sealed in its last position. And the Converter is so sensitive that its dead band is less than 0.1%.

C. A. T. Electro-pneumatic Control may well be the answer to your control needs. For details, write for Folder ND4(8). The address—Leeds & Northrup Co., 4923 Stenton Ave., Phila. 44, Pa.

LEEDS [N] NORTHRUP
instruments — automatic controls • furnaces

For more data on advertised products, use Readers' Service Cards, last page.

You ought to see the skeletons in our closet

We've got thousands of them and we are mighty careful to see that they don't rattle around and get lost

They are X-rays of what might be called the "bone structure" of an ACF-DURADOME tank car . . . actual pictures of the vital weldments which join together the heavy gauge steel.

The seams in ACF tank cars are butt welded inside and out . . . then X-rayed to assure perfect weldments throughout. These X-rays are part of the *permanent* record of every completed tank car which leaves our shops. They're your assurance that ACF builds the most rugged tank cars on the rails today.

Our job is leasing, selling and maintaining tank car fleets for industry. You'll find a nationwide network of Shippers' Car Line offices and repair shops ready to serve you. Our modern tank car service has been developed through decades of service to industry. Whether you prefer to lease or buy . . . contact your nearest Shippers' representative.

SHIPPERS SHPX CAR LINE

SHIPPERS' CAR LINE CORPORATION

A subsidiary of ACF INDUSTRIES, Incorporated

30 Church Street, New York 7, N. Y.

CHICAGO, ILL. · HOUSTON, TEX. · SAN FRANCISCO, CAL. · MILTON, PA. · EAST ST. LOUIS, ILL. · SMACKOVER, ARK. · TULSA, OKLA. · NORTH KANSAS CITY, MO. · RED HOUSE, W. VA.

Retubing? Rely on

keep Heat

First for Lasting Quality—from Mine to Market!

Phelps Dodge COPPER-BASE ALLOY Tubes to

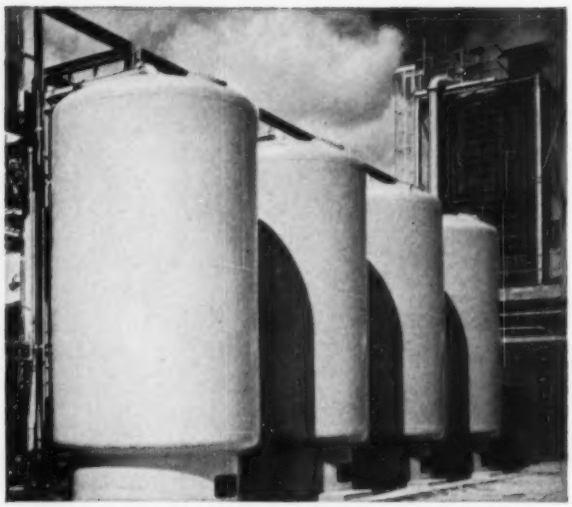
your Exchangers On-Stream!

- **Complete line of copper-base alloys** including Bi-Metal combinations to meet special corrosive conditions.
- **Speedy delivery** from strategically-located warehouses.
- **Careful analysis of your corrosion problems** by experienced engineering staff.
- **Quality-controlled fabrication** to assure finest tube properties.
- **Information and sales service** available from nearest Phelps Dodge district office.*

PHELPS DODGE COPPER PRODUCTS CORPORATION

*SALES OFFICES: Atlanta, Birmingham, Ala., Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle Washington, D. C.

ENGINEERING. Permutit engineers work with your staff or your consulting engineers to design all or any part of your water conditioning system.



EQUIPMENT. Permutit supplies complete equipment. Critical parts such as valves, chemical feeders and controls are designed and made by Permutit.

How Permutit® Solves a Water Problem

U. S. industry is faced with using lower grade water. Results: possible boiler scale, turbine deposits, corrosion of pumps and piping . . . also stains, blisters and other problems in plating, rinsing, dyeing and chemical processing.

• **For expert answers,** more and more management men and their consultants are buying the complete service offered by leading water-conditioning firms. Here's how Permutit (rhymes with "compute it"), a pioneer and largest in the field, tackles a water problem:

• **Water analysis,** study of the problem and past experience provide data on possible methods of treatment. The process offering the best balance of initial and operating cost vs desired quality of treated water is selected.

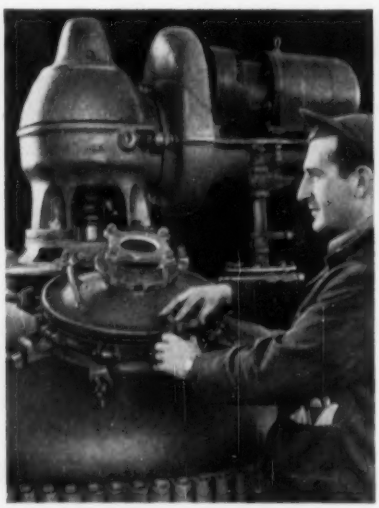
• **Complete proposal** by Permutit engineers covers type, size and capacity of equipment, price, any special engineering services and performance guarantees.

• **Manufacturing** – After the proposal is accepted, Permutit designs the entire project, schedules assembly and shipping. Critical parts, ion exchange resins, control panels are all made in Permutit plants. (No other U. S. firm makes all these components.)

• **Test runs** – Where required, Permutit checks the installation, supervises start-up and initial operation, trains permanent operating personnel.

• **For further information** look up the Permutit office in your city or write to The Permutit Company, Dept. PR-5, 330 West 42nd St., New York 36, N. Y.

WATER ANALYSIS. Permutit's modern water-analysis laboratory tests over 1200 samples a month!



ION EXCHANGE RESINS. Permutit makes its own ion exchange resins, natural and synthetic zeolites.

AUTOMATIC CONTROLS to ensure optimum results are designed, assembled, wired and tested by Permutit.

(Advertisement)

For more data on advertised products, use Readers' Service Cards, last page.

Quaker

Transferring fuel at sea is smooth sailing with durable, abrasion resistant submarine hose

Your Quaker-Quaker Pioneer distributor can save you inventory expense, storage and freight charges. Look him up in the classified phone book—or write directly to us for his name and free brochure.

Put uninterrupted fuel flow between ship and barge with this rugged rough-bore, three-wire submarine hose. Tube is heavy gauge, oil-resistant Neoprene with retaining wall of single-ply close-woven fabric to insure uniform thickness of tube. Flat wire is wrapped flush on outside cover to withstand severe pounding and abrasion. Extra strength provided by reinforcement consisting of multiple plies of heavy woven duck frictioned with oil-resistant rubber. Carcass is protected by heavy-gauge rubber, resistant to oil and ageing. Ends are reinforced to prevent bending or breaking at nipples. In lengths up to 50 ft. Complete Quaker-Quaker Pioneer line also includes packing, belting and moulded rubber for every use.

HKP H. K. PORTER COMPANY, INC.

QUAKER RUBBER DIVISION
Philadelphia 24, Pa.

QUAKER PIONEER RUBBER DIVISION
San Francisco 7, California

For more data on advertised products, use Readers' Service Cards, last page.

ONE OF THE DRESSER INDUSTRIES

CLARK

CLARK BROS. CO., Olean, New York—Gas turbines, engines, and reciprocating, centrifugal and axial flow compressors — gas, steam, electric and diesel driven.

DRESSER IDECO

DRESSER-IDECO DIVISION, Columbus, Ohio — Radio and television broadcasting towers, steel buildings, aircraft hangars, mechanical parking garages, electric power substations.

DRESSER MANUFACTURING DIVISION

DRESSER MANUFACTURING DIVISION, Bradford, Pa. — Pipe line couplings, pipe repair sleeves and clamps, weldments, forgings, welding fittings, flanges, rings.

IDECO

IDECO, Dallas, Tex.—Hydrair and Power Rigs; Full-View Masts; Substructures; Single, Dual and Drive-In Rambler Rigs; Blocks, Swivels, Rotaries; Mud Pumps; Petroleum Equipment and Supplies.

Magcobar.

MAGNET COVE BARIUM CORP., Houston, Tex.—Magcobar and Magcogel drilling muds and other specialized oil well drilling fluids and chemicals.

PACIFIC

PACIFIC PUMPS, INC., Huntington Park, Calif — Centrifugal pumps for refineries, power stations, pipelines, and chemical plants; plunger pumps for oilwells.

ROOTS-CONNERSVILLE

ROOTS-CONNERSVILLE BLOWER DIVISION, Connersville, Ind.— Rotary positive blowers, gas pumps, centrifugal blowers, exhausters, and positive displacement meters.

Security

SECURITY ENGINEERING DIVISION, Dallas, Tex., Whittier, Calif. — Rock bits, reamer rock bits and hole openers; reamers, casing scrapers and Neo-Red rubber stabilizers.

Tomorrow's progress planned today

Look for this symbol

...it identifies all Dresser Companies and their products... it is your guarantee of the DRESSER *plus+*

You gain an important extra plus value every time you are served by any of the Dresser companies. This is the unique way Dresser operates to serve you better. Each Dresser company works independently to assure maximum individual attention to your specific needs . . . yet all are teamed together in a single organization to provide a group of research, engineering, and manufacturing services. From Dresser you obtain equipment based on the over-all experience of many companies in many industries.

As performance demands on equipment become increasingly greater, Dresser will continue to pace the technological changes in your field. You can count on the Dresser companies as major suppliers of equipment researched and developed to serve you better and meet your future needs.

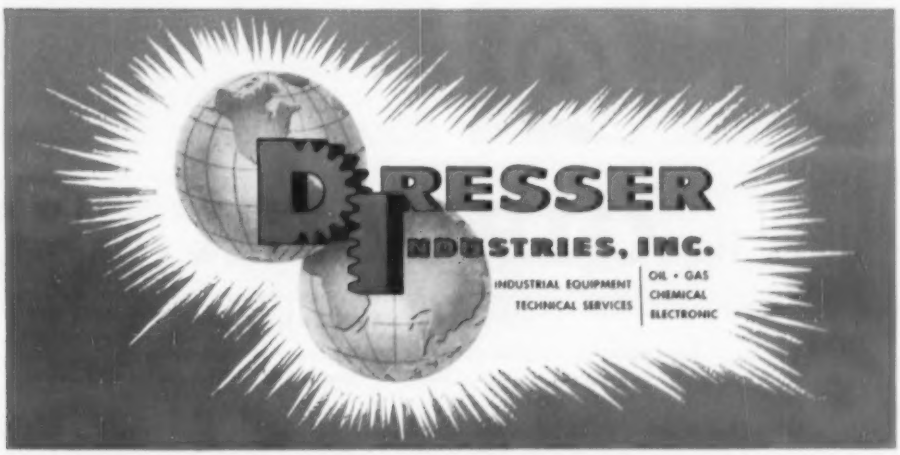
Wherever you are, whatever your needs, specify equipment from Dresser companies. No other single organization offers you the same broad range of "know-how" coupled with individual company attention to these specific needs. Be sure to look for this symbol – it's your guarantee of the Dresser *Plus+* . . . the mark of superior equipment and services which have become the standard of comparison the world over.

LANE WELLS

LANE-WELLS CO., Los Angeles, Calif., Houston, Tex., Oklahoma City, Okla.—Electric and Radioactivity Well Logging, Koneshot perforating and bullet perforating, packers and bridging plugs.

SIE

SOUTHWESTERN INDUSTRIAL ELECTRONICS, Houston, Tex.—Seismograph systems and instruments—electronic, electro-mechanical. Computers—analog and digital; recording systems. Special transformers, reactors.

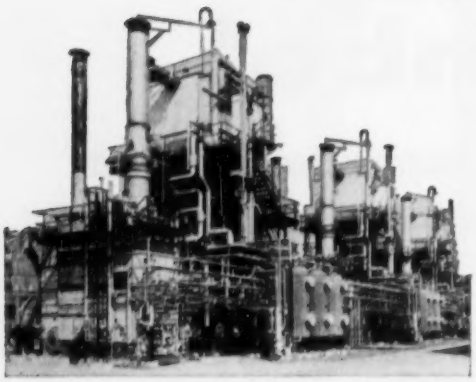


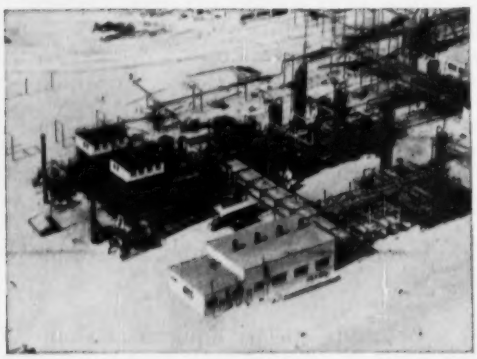
REPUBLIC NATIONAL BANK BUILDING • POST OFFICE BOX 718 • DALLAS 21, TEXAS

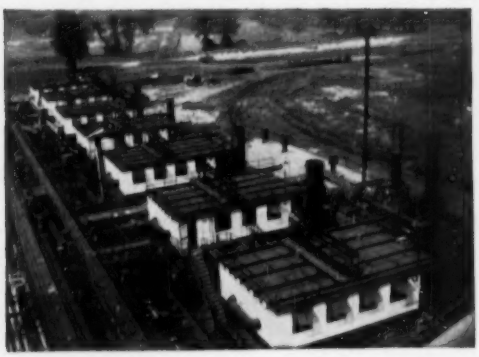
HYDROGEN

...how much do you need?

Girdler offers you complete engineering-construction service for BIG-CAPACITY *plants*







When you plan facilities for "tonnage hydrogen" for treatment of refinery feed stocks and hydrocarbon products, it will pay you to take advantage of Girdler experience.

Big plant experience: Girdler has designed and constructed large plants for petroleum products and chemicals. Two hydrogen plants have been built each of which can produce gas at the rate of seventy million cubic feet per day. More than 45 Girdler hydrogen plants are giving outstanding performance in the United States and Canada.

Girdler manufactures all of the catalysts used in Girdler hydrogen plants. These catalysts permit high production rates.

Call or write for complete information

the **GIRDLER** Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION • DISTRICT OFFICES: New York, San Francisco

What Makes Furfural So Good As a Selective Solvent?

1. SELECTIVITY: Furfural is highly selective; it is a polar molecule and gives a sharp separation. Its high specific gravity permits rapid phase separation.

2. EASE OF RECOVERY: Furfural may be readily recovered from aqueous solution by steam stripping; it may be recovered from non-aqueous solutions either by flash vaporization, straight distillation, steam stripping, or extraction with water.

3. STABILITY: Under the conditions encountered in refining, furfural has a high degree of stability, as shown by the low solvent losses in operating plants around the world.

4. STORAGE: It is not necessary to use special handling precautions for cold weather operation since furfural has a freezing point of −34°F. which is well below temperatures normally encountered. Generally, furfural is stored and handled in steel tanks and lines.

5. SAFETY: Furfural has a safety record extending over 30 years of industrial use. It has a high flash point (150-160°F.), and a vapor pressure of 8 mm. Hg at 39.9°C.

6. COST: Furfural is low in price, and with high recovery, overall solvent costs are attractively low.

7. AVAILABILITY: Large quantities of furfural are produced the year around at three plants from raw materials which are replaceable yearly.

If you would like to know more about the properties of furfural, write for our Bulletin 203 "Physical Data on Furfural."

The Quaker Oats Company — **CHEMICALS DEPT.**

340Q The Merchandise Mart, Chicago 54, Illinois
Room 540Q, 120 Wall St., New York 5, N. Y.
Room 440Q, P. O. Box 4376, Portland 8, Oregon

In the United Kingdom: Imperial Chemical Industries Ltd., Billingham, England • **In Europe:** Quaker Oats-Graanproducten N.V., Rotterdam, The Netherlands; Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France; A/S "Ota", Copenhagen, S. Denmark
In Australia: Swift & Company, Pty., Ltd., Sydney • **In Japan:** F. Kanematsu & Company Ltd., Tokyo

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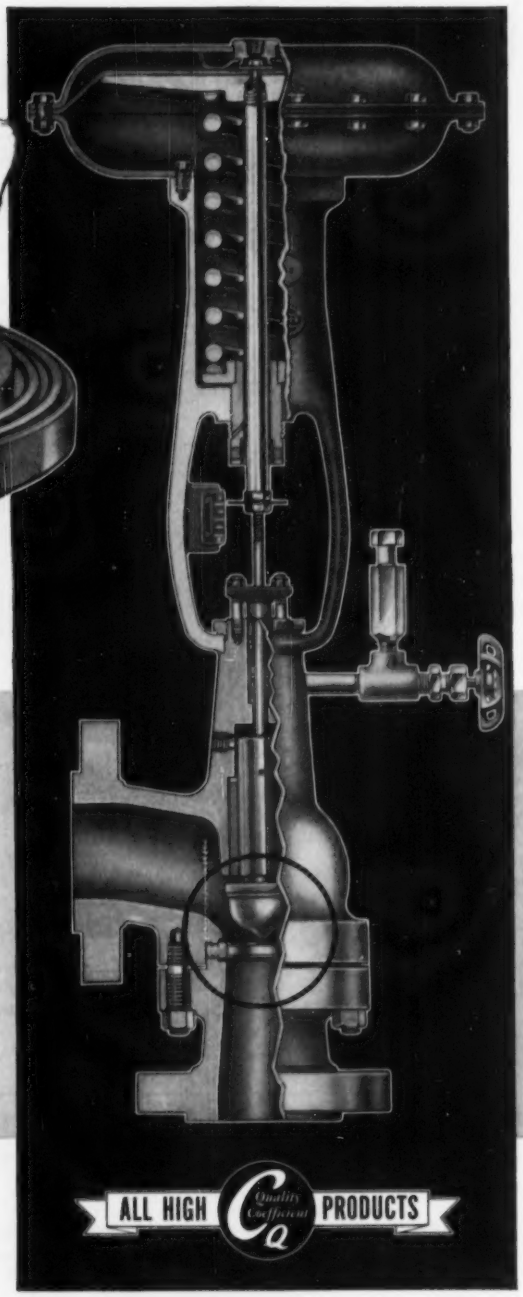
Masoneilan

"These Exclusive Better Service,



SPECIFICATIONS:

777 SERIES CONTROL VALVE

Material:	Cast steel or cast iron
Size:	1″ to 6″
Connections:	Flanged
Rating:	Cast steel — ASA 150, 300, 400, 600 lb. Cast iron — ASA class 125, 250

Available with direct motor (No. 777-19) or reverse motor (No. 778-19) and with finned bonnet construction.

PLUS values . . .

Design Features Insure Greater Flexibility"

Here are the three big reasons you get more for your money with Masoneilan angle valves . . .

REVERSIBLE SEAT RING has ground and lapped gasketless joint assuring accurate centering, vertical alignment and tightness. Provides new seating surface quickly when needed, shortens downtime.

REDUCED CAPACITY plugs and seat rings available in .4 Factor standard reduction. Also in .7 Factor for added flexibility in 6″ valves used in high pressure-drop service; and in $.4^2$ Factor (capacity ratio .16); and in $.4^3$ Factor (capacity ratio .06) for use on small flow applications.

PLUG GUIDING IS HEAVY DUTY, large diameter guide section with minimum length of two guide diameters operating in hardened stainless steel bushing.

Masoneilan 777 series Control Valves are well suited for slurry service, in heater drainer service where flashing may occur, and on soot blower applications. Their streamlined, non-clogging inner contours cut down erosion and reduce turbulence.

It will pay you to get the story on *all* Masoneilan Control Valve *plus* features. They add up to extra value and true cost reduction. Call your nearest Mason-Neilan representative or write:

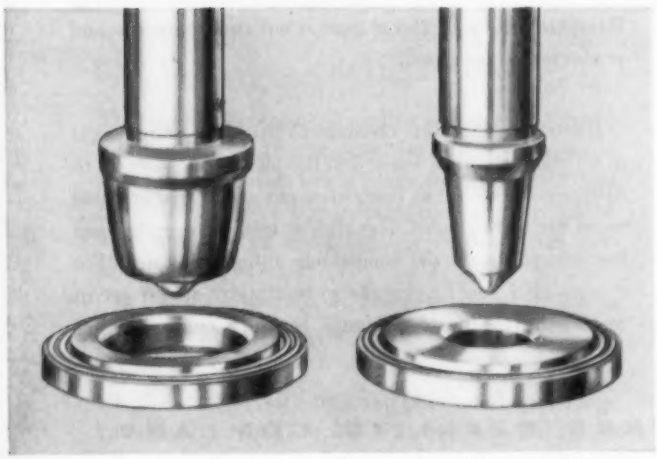
MASON-NEILAN

MASONEILAN

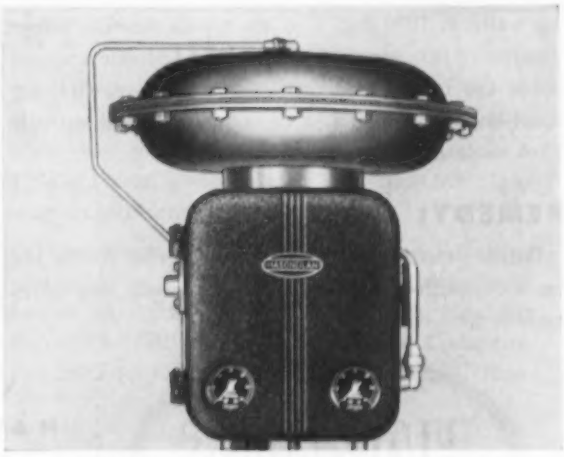
Division of Worthington Corporation

51 NAHATAN STREET, NORWOOD, MASS.

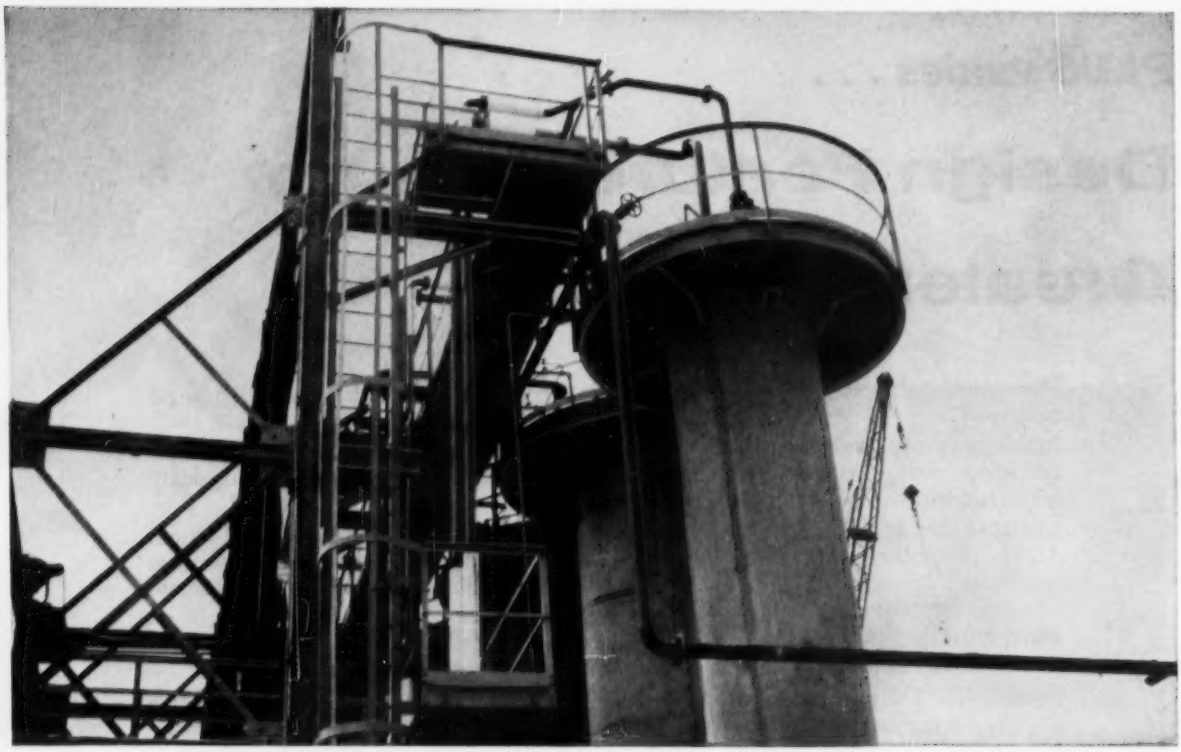
Sales Offices or Distributors in the Following Cities: New York • Syracuse • Chicago • St. Louis • Tulsa • Philadelphia Houston • Pittsburgh • Atlanta • Cleveland • Cincinnati • Detroit • San Francisco • Boise • Louisville • Salt Lake City El Paso • Albuquerque • Odessa • Charlotte • Los Angeles • Corpus Christi • Denver • Appleton • Birmingham New Orleans • Dallas • Seattle • Mason-Neilan Regulator Co., Ltd., Montreal and Toronto



Full capacity and .4 Factor plugs and seat rings are interchangeable in standard body, as are other reduced capacity plugs and seat rings. They are all precisely sized for accurate fit and alignment.



New 2800 series (Model 2807 shown) Pressure Controllers offer (1) fast response, (2) high sensitivity, (3) low cost and (4) proportional band of 1 to 30%.



HASTELLOY Alloy B Handles Hydrogen Chloride at 1000 deg. F

PROBLEM:

Handling highly-reactive hydrogen chloride gas containing water at 1000 deg. F at the top of chlorine burner towers used in making hydrochloric acid. Chlorine is burned inside the towers in a hydrogen atmosphere. Ordinary materials used at the top of these burners would last only a few weeks at best.

REMEDY:

Burner covers are made of HASTELLOY alloy B. The hot gas is channelled through a cast cross, piping, and valves made of alloy B.

RESULT:

30 to 40 times longer service is given by the parts of HASTELLOY alloy B. Down time is cut to a minimum and production is increased.

HASTELLOY alloy B is resistant to hydrogen chloride gas at high temperatures, wet or dry. It is also highly resistant to hydrochloric acid in all concentrations and at temperatures up to the boiling point. The alloy is readily fabricated and has strength properties comparable to high-alloy steel. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company office.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" and "Hastelloy" are registered trade-marks of Union Carbide and Carbon Corporation

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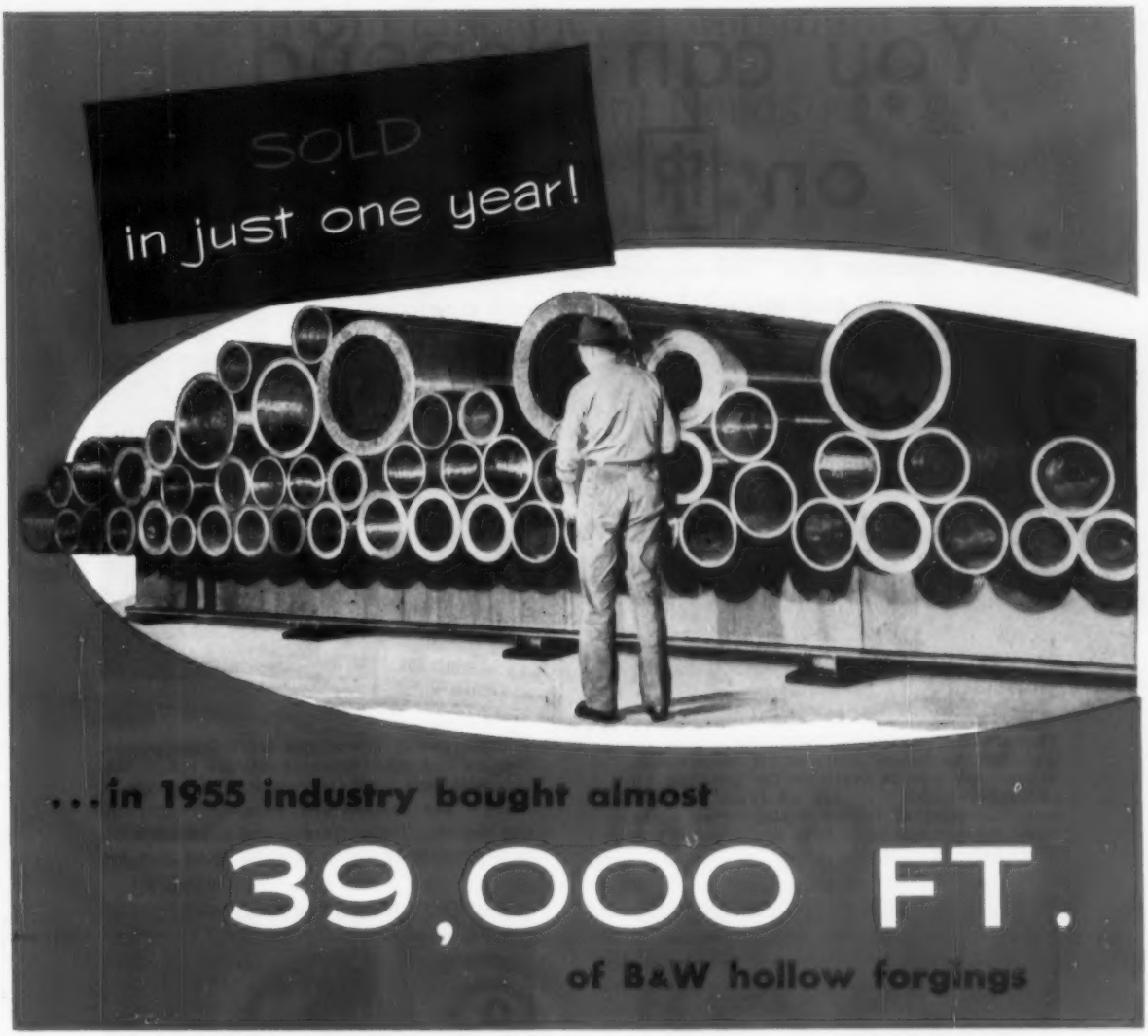


This is an acceptance story that is more than seven miles in length! In one year, the power, petroleum and chemical industries placed orders for B&W Hollow Forgings in quantities measured by miles. The measure of their quality is based on two always-present facts:

1) B&W's unparalleled manufacturing facilities;
2) B&W's acceptance of small and large orders for definite delivery dates.

B&W Hollow Forgings are produced in a large range of fractional inch sizes and a selected range of standard pipe sizes in accordance with the following ASTM Specifications: A 106-52T seamless carbon-steel pipe for high-temperature service. Seamless drum forgings of A 266-54 carbon-steel. A 312-54T seamless and welded austenitic stainless steel pipe. A 335-53T seamless ferritic alloy steel pipe for high-temperature service. A 376-54T seamless austenitic steel pipe for high-temperature central-station service.

For the complete range of B&W Hollow Forgings plus other important information on what B&W has to offer you in Hollow Forgings, send for Bulletin S-16B. The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.

BABCOCK & WILCOX

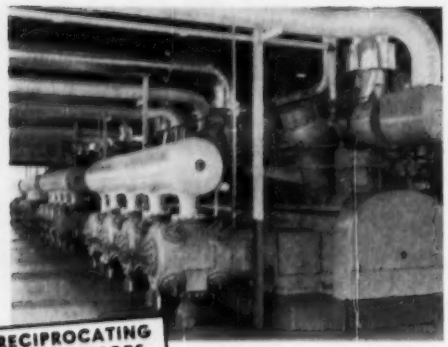
BOILER DIVISION

S-455

For more data on advertised products, use Readers' Service Cards, last page.

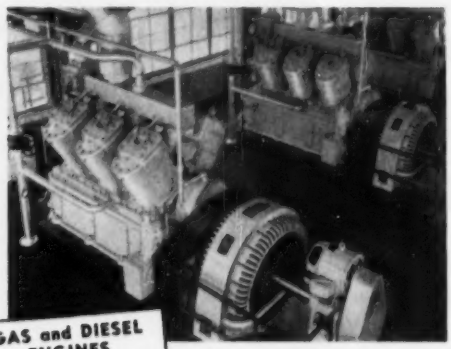
You can depend on I-R equipment

. . . because it's "job-engineered" with design, construction and materials to meet each application



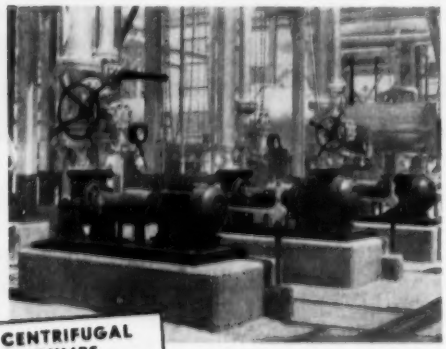
RECIPROCATING COMPRESSORS

Thousands of successful installations have established the dependability of I-R compressors. A complete line is available for handling air and other gases . . . for all types of drive including integral 4-cycle engine-driven units. Sizes range from ½ to 6000 hp; pressures to 35,000 psi.



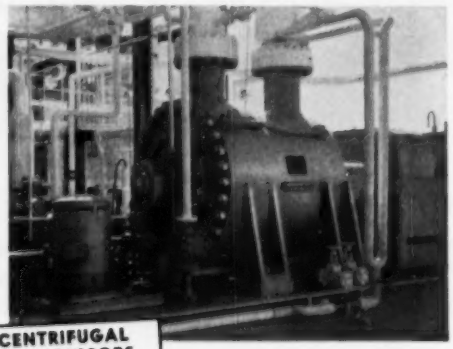
GAS and DIESEL ENGINES

For generating power and for driving pumps, blowers and other types of rotative equipment, Ingersoll-Rand builds a complete line of 4-cycle, V-angle gas engines and 4-cycle, cylinders-in-line diesels. Turbo-charged and naturally aspirated models available in sizes up to 2000 hp.



CENTRIFUGAL PUMPS

For moving liquids in refineries and through pipe lines, Ingersoll-Rand offers a complete line of centrifugal pumps. Single and multi-stage, horizontal and vertical units are available . . . many with built-in mechanical seals. Sizes for all pressures and capacities; for hot and cold liquid service; for all types of drive.



CENTRIFUGAL COMPRESSORS

A complete line of single and multi-stage centrifugal compressors and Turbo-Blowers is made by I-R for catalytic cracking, reforming processes, pipe-line service and for other air and gas applications. Capacities to 160,000 cfm; pressures to 2200 psi. Horizontally split and barrel types are available.

Ingersoll-Rand

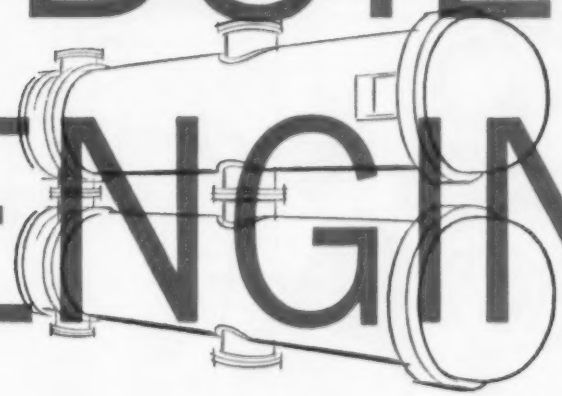
11 BROADWAY, NEW YORK 4, N. Y. 14-311

Here's a suggestion: Ask your nearest Ingersoll-Rand engineer to tell you more about I-R equipment and how it can best meet your requirements. There are very few phases of petroleum production, refining and transmission that can't benefit in some way from the proved economy and dependability of I-R equipment.

COMPRESSORS . CONDENSERS . PUMPS . DIESEL ENGINES . AIR AND ELECTRIC TOOLS . VACUUM EQUIPMENT

For Optimum Efficiency at Minimum Cost, Heat Transfer Equipment Needs Kellogg's

BUILT-IN ENGINEER



WHEN a process plant's efficiency, and even its economic success, depends on the performance of heat exchangers, this vital equipment becomes more than a "packaged" item or even a matter of following specifications. Optimum performance, at minimum cost to the customer, demands all of the extra know-how, know-when, and know-where that the fabricator can put into the job. It requires, for example, a thorough knowledge of heat transfer, stress analysis, metal fatigue, corrosion control, metallurgy, and welding techniques, plus the inherent ability to apply this knowledge to the specific problem at hand.

At M. W. Kellogg, the instinctive application of this kind of knowledge—which goes into the design and fabrication of every Kellogg heat exchanger or other processing unit, is what we call the "built-in engineer". This important extra, together with Kellogg's other facilities guarantees performance, minimizes maintenance, and often reduces initial costs. In one recent instance, a saving of $5,000 for a customer resulted from a slight change in design suggested by Kellogg's staff.

We welcome the opportunity to demonstrate, in cooperation with your own design engineers or alone, what Kellogg's "built-in engineer" can contribute to *your* new process equipment.

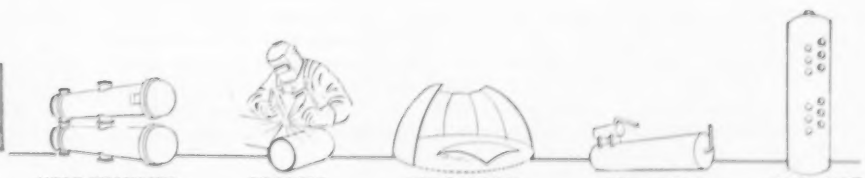
Fabricated Products Division

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17, N. Y.

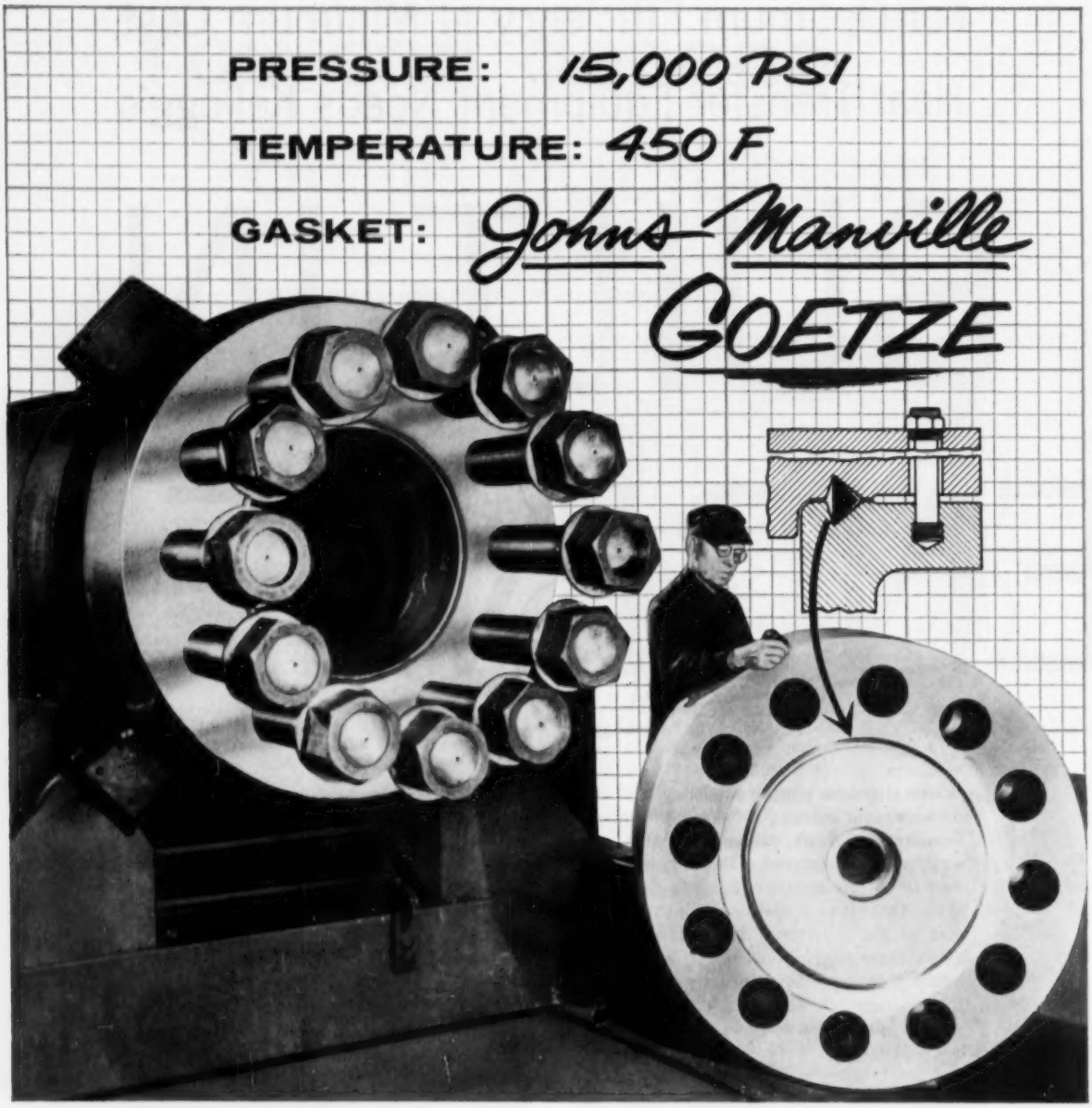
The Canadian Kellogg Company, Limited, Toronto • Kellogg International Corporation, London

SUBSIDIARIES OF PULLMAN INCORPORATED

M KELLOGG W



For more data on advertised products, use Readers' Service Cards, last page.



How A. O. Smith maintains tight seals in giant "Multi-Layer" vessels

Today's tremendous pressures and temperatures have placed special demands on manufacturers of processing equipment. A. O. Smith has answered this need with a special type of "Multi-Layer" vessel construction. And Johns-Manville in turn has provided gaskets that assure tight seals under these exacting conditions. Typical of these is the delta type gasket, illustrated above, which was designed, for this application, to withstand pressures up to 15,000 psi. and temperatures to 500 F.

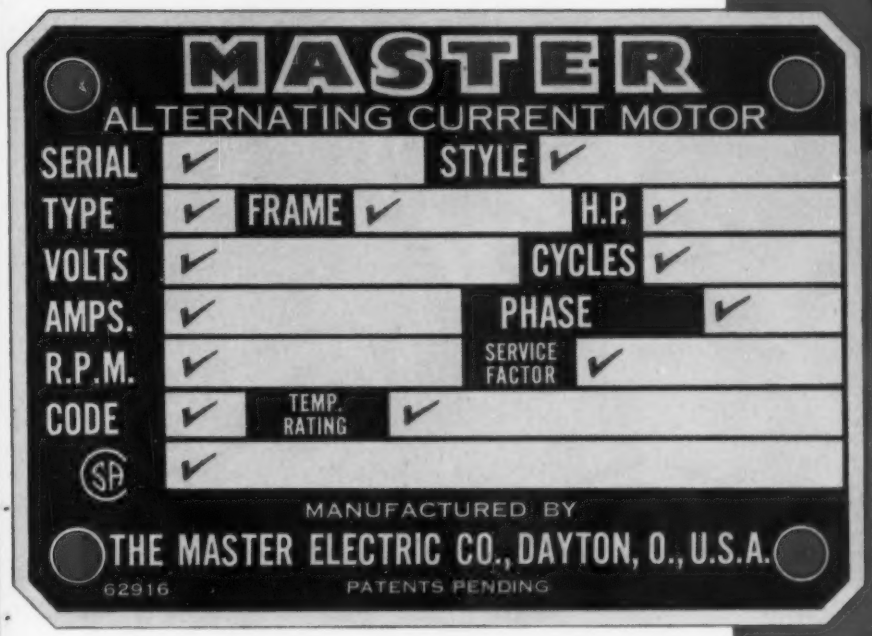
The development of special gaskets to meet special purposes has been the stock in trade of Johns-Manville's Goetze division for more than sixty-five years. Expert technicians possess a knowledge of metals and other factors related to gasket design and performance that is unmatched in the field. What's more, intensive specialization and modern production tooling provide substantial cost savings on J-M gaskets.

If you need gaskets for high pressure vessels for similar applications, send us a drawing or template for quotation. If you have a sealing problem of any kind, J-M technicians will work directly with your own engineers to develop new gaskets —or adapt existing styles—to meet your specific requirements. Write for further information to Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit (Toronto), Ontario.

Johns-Manville PACKINGS & GASKETS

For more data on advertised products, use Readers' Service Cards, last page.

Write your own ticket—



What are your power drive requirements? Here at Master, with the widest selection in the nation to choose from, you're sure to fill your needs quickest and best.

Need something special in gear reduction—electric brakes—variable speed operation—fluid drive or special mounting? Or would some of our standard models (⅛ to 400 H.P.) fill the bill? You'll find the answer here! And remember, all Master components are engineered to form combinations of units in one streamlined, compact package of efficiency. Name your need and the name that fills it is Master—for greater salability of motor driven products; for increased productivity of plant equipment.

Motor Ratings..⅛ to 400 H.P. All phases, voltages and frequencies.

Motor Types.....Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current.

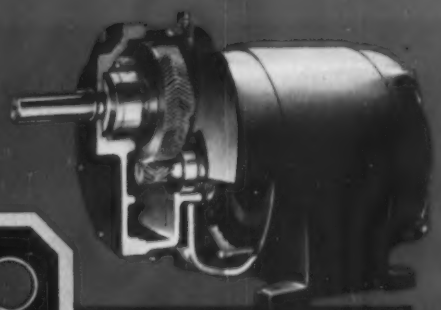
Construction ....Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose.

Speeds .....Single speed, multi-speed, and variable speed.

Installation .....Horizontal or vertical, with or without flanges and other features.

Power Drive Features .....Electric brakes (2 types)— 5 types of gear reduction up to 432 to 1 ratio. Mechanically and electronically-controlled variable speed units—fluid drives—every type of mounting.

THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO

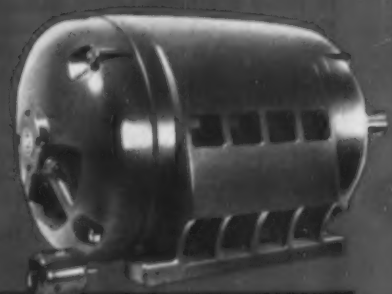


Parallel Shaft Gearmotors

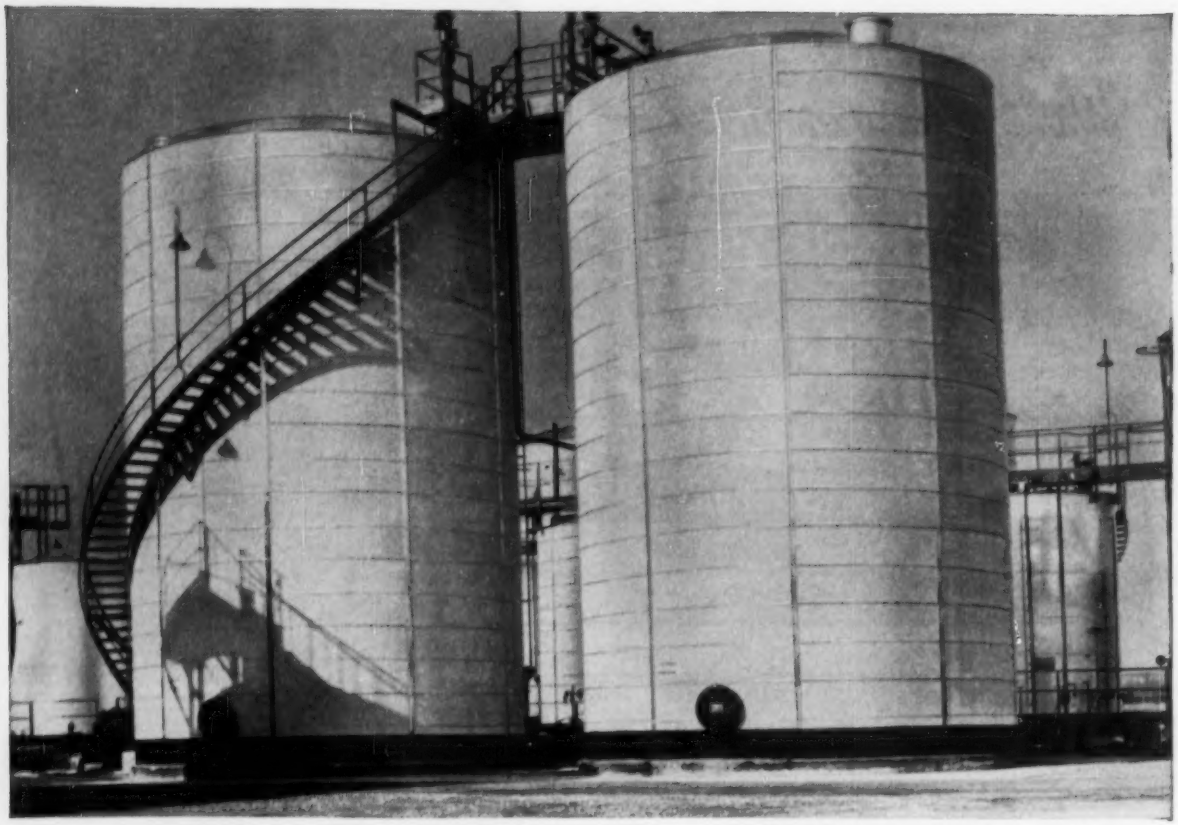
Right-Angle Shaft Gearmotors

Unibrake Motors

Speedrangers



Standard Motors— ⅛ to 400 H.P.



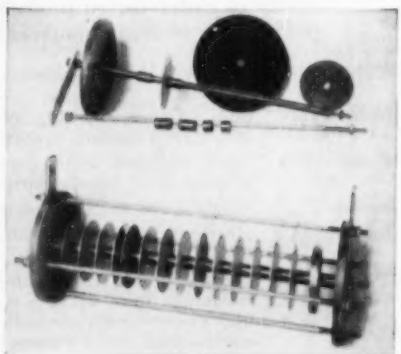
In these nickel-clad tanks, phenol synthesized from cumene is kept pure for long periods. Run-down tanks used to check the product against specifications as it comes off stream are also nickel-clad.

Nickel-cladding guards phenol purity in new synthetic plant

With phenol, metallic pick-up alienates customers.

That's why engineers, in designing one of America's newest synthetic phenol plants for Standard Oil Company of California, made these two big storage tanks . . . and three run-down tanks . . . of nickel-clad steel. The synthetic produced is marketed by Standard's subsidiary, Oronite Chemical Company.

Experience over the years has proved that phenol can be stored in nickel or nickel-clad steel for prolonged periods with negligible metal pick-up. Phenol stays premium-market pure, color excellent . . . a big factor in keeping customers for 35,000,000 pounds of product per year happy.



Good in production, too

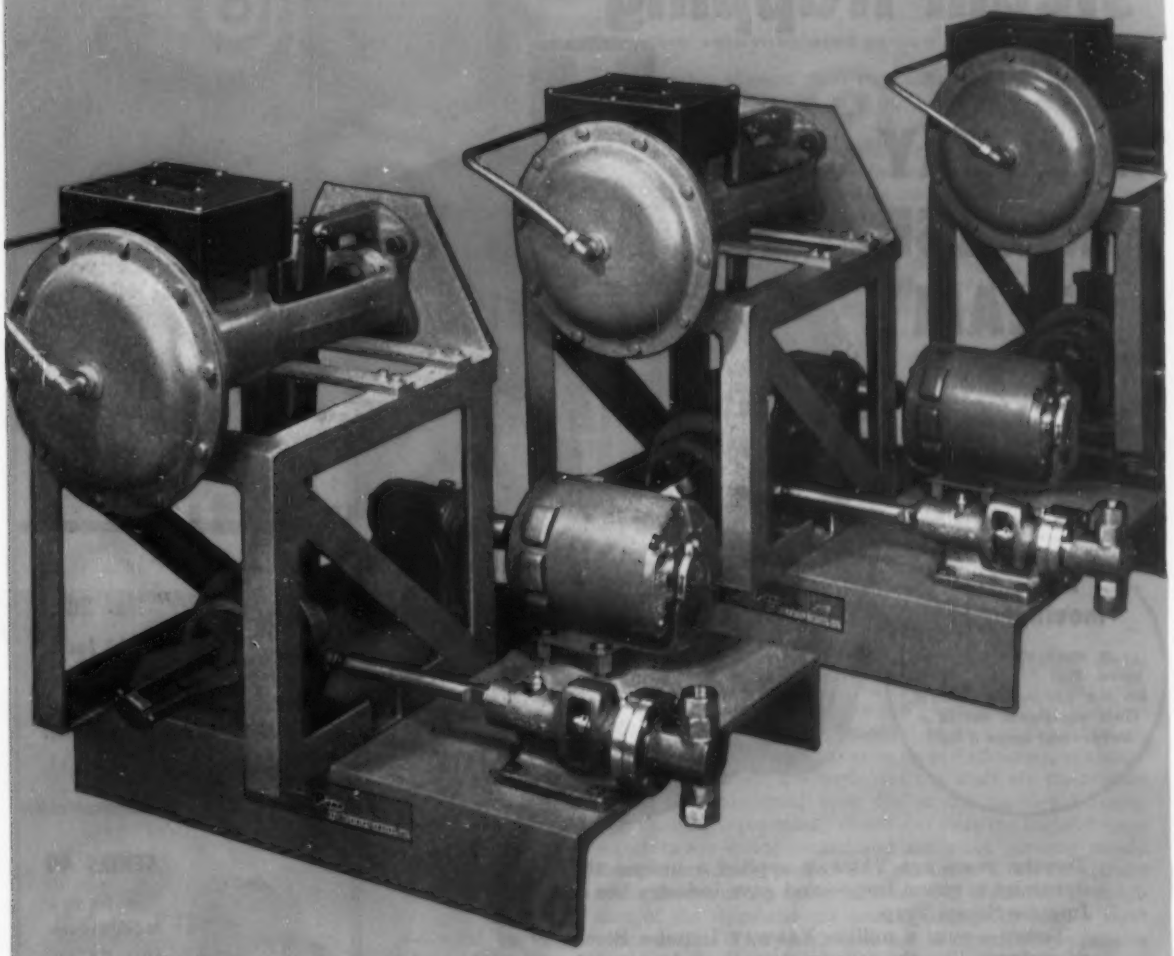
In many synthetic plants, nickel and high-nickel alloys, such as Monel®, a nickel-copper alloy, are also used in reactors and other items of production equipment. These alloys possess high resistance to corrosion by acids, caustic soda and many other corrosive chemicals.

Do you have a corrosion or purity problem connected with the manufacture or handling of phenol? Write to Inco's Corrosion Engineering Section. They will be glad to give you the benefit of their experience and research without cost or obligation.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO TRADE MARK **Nickel**... for purity

Pumping Corrosion Inhibitors..



..with metering accuracy of 0.2%

thanks to **PHILATROL***

AUTOMATIC CAPACITY CONTROL

* Illustrated, pneumatically motivated with built-in square root extractor requiring 3 to 15 lb. signal. Also available electrically motivated—50 or 100 ohm slide wire. Hydraulically motivated —50 to 100 p.s.i. hydraulic fluid.

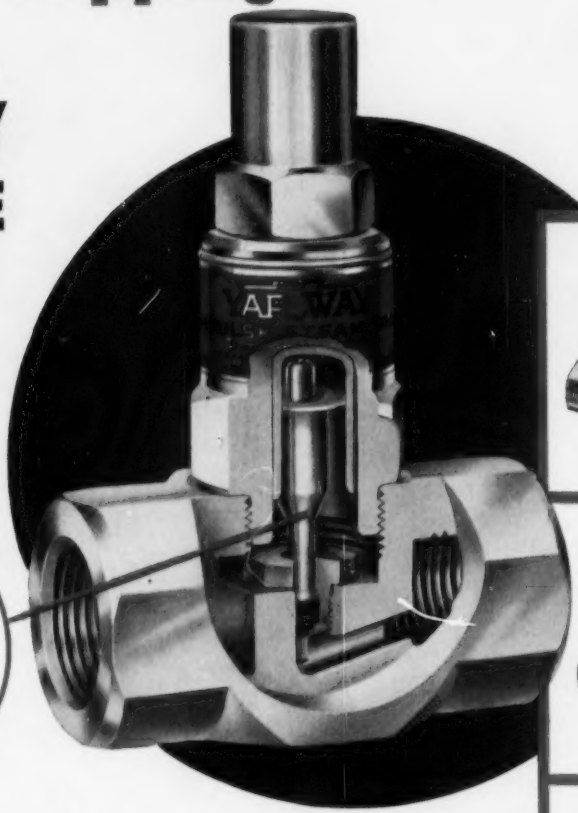
PHILADELPHIA PUMPS

PHILADELPHIA PUMP & MACHINERY CO. / 1513 Race St., Phila., Pa. / Subsidiary of American Meter Co.

For more data on advertised products, use Readers' Service Cards, last page.

the impulse that revolutionized steam trapping

YARWAY IMPULSE STEAM TRAP



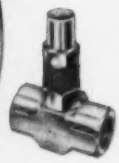
the only moving part

...a small stainless steel valve that literally floats on the condensate load. Gets equipment *hot in a hurry*—and *keeps it hot!*

SERIES 60 and 120

For all *normal* trap requirements, pressures to 400 and 600 psi.

½" No. 20-A

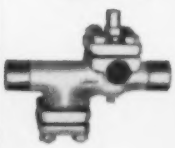


For *light loads* on tracer lines, steam mains, small presses, etc.

SERIES 40

For *heavy loads* requiring extra high capacity steam traps.

INTEGRAL-STRAINER HIGH PRESSURE TRAP



For *high pressures, high temperatures.* (Flanged or welding connections.)

Twenty years ago YARWAY applied a unique theory of thermodynamics to steam traps—and gave industry the amazing YARWAY Impulse Steam Trap.

Today — over a million YARWAY Impulse Steam Traps later — advantages like the following continue to convert new users, and convince old users to standardize on the YARWAY Impulse:

- QUICK HEAT-UP AND EVEN TEMPERATURES OF EQUIPMENT
- GOOD FOR ALL PRESSURES WITHOUT CHANGE OF VALVE OR SEAT
- SMALL SIZE—LIGHT WEIGHT
- ONLY ONE MOVING PART
- STAINLESS STEEL—minimum maintenance
- WON'T FREEZE UP
- A COMPLETE LINE of sizes and types for every requirement
- IMMEDIATELY AVAILABLE from 270 local Industrial Distributors

For free Trap Selector, or 24 page Bulletin, write

YARNALL-WARING COMPANY
128 Mermaid Avenue, Philadelphia 18, Pa.

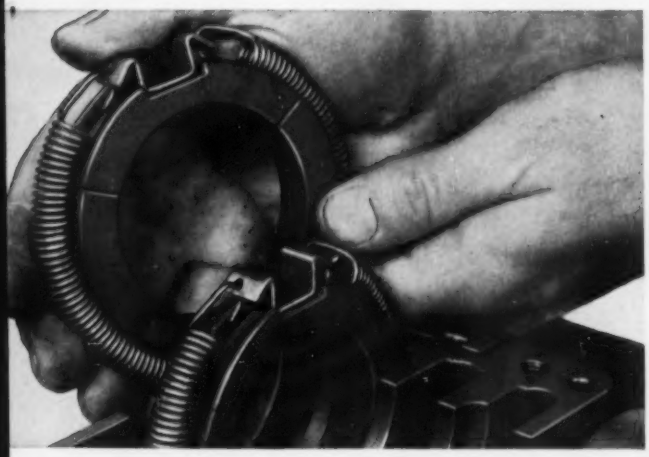
YARWAY IMPULSE® STEAM TRAP

OVER 1,000,000 YARWAY IMPULSE STEAM TRAPS USED

For more data on advertised products, use Readers' Service Cards, last page.

On all General Electric High-speed Turbines,

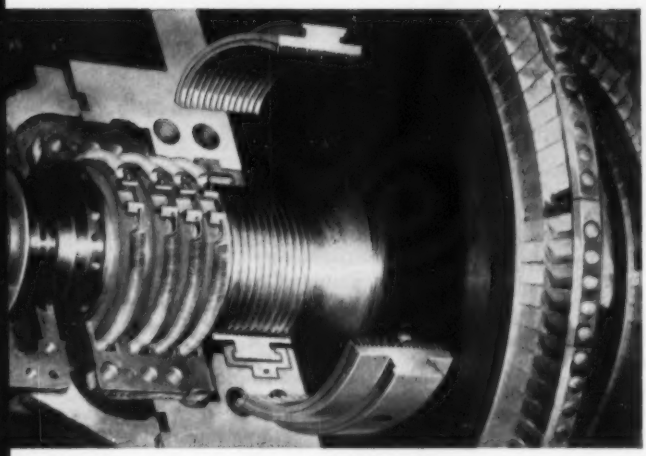
Well-designed, efficient seals...



Low-cost, easily-replaced carbon packings

For the most efficient shaft-end sealing, well-designed, low-cost carbon packings are used on G-E High-speed Turbines to seal steam pressures up to 75 psig. Made of non-galling, self-lubricating carbon-graphite, these segmental rings have high mechanical strength in the small sizes used, assuring long life under normal operating conditions. A garter spring in an offset "V" groove holds each ring together and presses it firmly against the side of the chamber, forming a tight seal. This unique arrangement permits the rings to support their own weight and to adjust themselves to the shaft position, thereby reducing wear and increasing the life of the seal. The rings are contained in compact external packing boxes, and can be easily inspected or replaced without breaking the horizontal joint of the wheel casing.

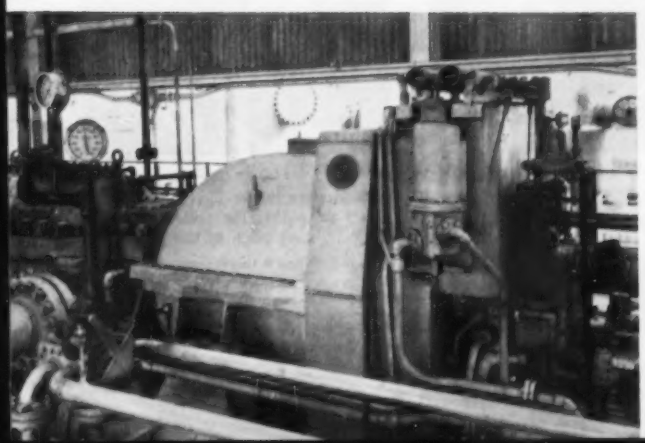
cut steam leakage...



Reliable, long-life metallic-labyrinth seals

To effectively minimize shaft-end steam leakage where shell pressures exceed 75 psig, segmental, high-low tooth metallic-labyrinth seals are used in combination with carbon packing. Between stages, straight-tooth metallic-labyrinth seals are always used. For maximum seal efficiency, minimum clearances between the teeth and the shaft are maintained by precision-machined hook fits in the packing housing. Shaft scoring is practically eliminated since the leaded-bronze segments are spring-backed and can move outward should there be accidental contact with the shaft. When unbalanced steam pressure forces axial movement of the seals, the shoulders of the rings and the housing engage to form a tight steam seal. All labyrinth seals are designed to compensate for thermal expansion, thus assuring a most efficient steam seal at operating temperatures.

reduce maintenance costs



The careful design and manufacture of these steam seals is your further assurance of low maintenance and consistent reliability of G-E High-speed Turbines. Why not check into the many other sound design features built into these mechanical drives? Your Apparatus Sales Representative will be glad to explain the many benefits they offer to your operation. Contact him for further information or write for Bulletin GEA-6232, General Electric Company, Section 241-7, Schenectady, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Jacketing forms around pipe easily. A two man crew can apply jacketing without special installation equipment. Aluminum strapping and seals make application simple and quick, reducing labor costs. Factory-attached moisture barrier is recommended where the presence of moisture could harm aluminum from the under side. The resin type adhesive used exclusively by Childers to bond moisture barrier to under side of jacketing withstands temperatures up to 300°F.

1,286 Plants in 48 States and 14 Foreign Countries

Insure Insulation Efficiency with Childers Jacketing

Leading engineers world-wide specify Childers Jacketing for protecting costly insulation on lines, towers, vessels and tanks. These efficiency minded engineers prefer Childers Jacketing because of these exclusive features:

1. LAP-SEAL (patents pending) insures a more positive weather-seal.
2. Heavy weight jacketing designed for lines subject to abuse.
3. Deep Corrugated Jacketing with factory-attached moisture barrier for towers, vessels and tanks.
4. New resin adhesive that makes a stronger bond between the jacketing and the vapor barrier.

Childers Aluminum Jacketing provides strong, durable protection with three way savings:

1. Lower first cost than any other permanent jacketing.
2. Lower application cost because it's so easy to cut-to-size and attach.
3. Eliminates maintenance because it is made of durable aluminum for maximum corrosion resistance and requires no painting.

Economy minded engineers know that plant efficiency is improved when costly insulation is protected with Childers Aluminum Jacketing. And too, the gleaming beauty of Childers Jacketing makes plants brighter, neater — reduces "housekeeping" costs.

Send for Free Sample and Prices

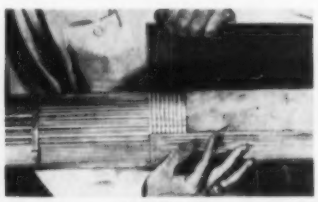
You can help increase the efficiency of your insulated lines, towers, vessels and tanks by using Childers Jacketing. Write today for free sample and engineering data. Childers Manufacturing Co., Dept. PR-34, Houston 8, Texas.

New Deep Corrugated Jacketing For Towers, Vessels and Tanks

Only Childers offers deep corrugated aluminum jacketing with factory-attached moisture barrier. Available in 1¼" and 2½" corrugations. Childers Deep Corrugated Jacketing is used to provide permanent protection for insulated towers, vessels and tanks.

Heavy Weight Jacketing

Only Childers offers .019" Jacketing in labor saving 4' wide rolls. This exclusive product is recommended to protect insulated lines along walkways and in other areas where they are subject to abuse; also recommended for protection of all insulated towers, vessels and tanks.



Lap-Seal

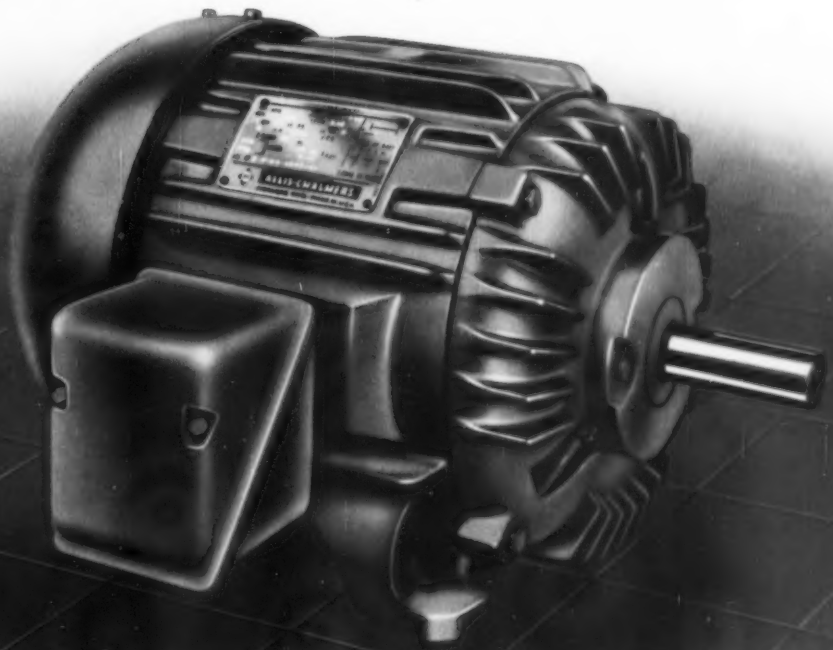
Childers exclusive LAP-SEAL is a series of eight ribs rolled into the underlapping edge of the jacketing.

Lap-Seal has 2 important advantages:

1. Where desired, a positive weather seal is easily made with Lap-Seal and a mastic.
2. Lap-Seal provides an automatic measure of the 2" circumferential lap. It saves labor, insures proper lap and prevents waste.

(Advertisement)

There's MORE *Cooling Surface* with Allis-Chalmers MOTORS



Why Rib-Type Motors Won't Fry

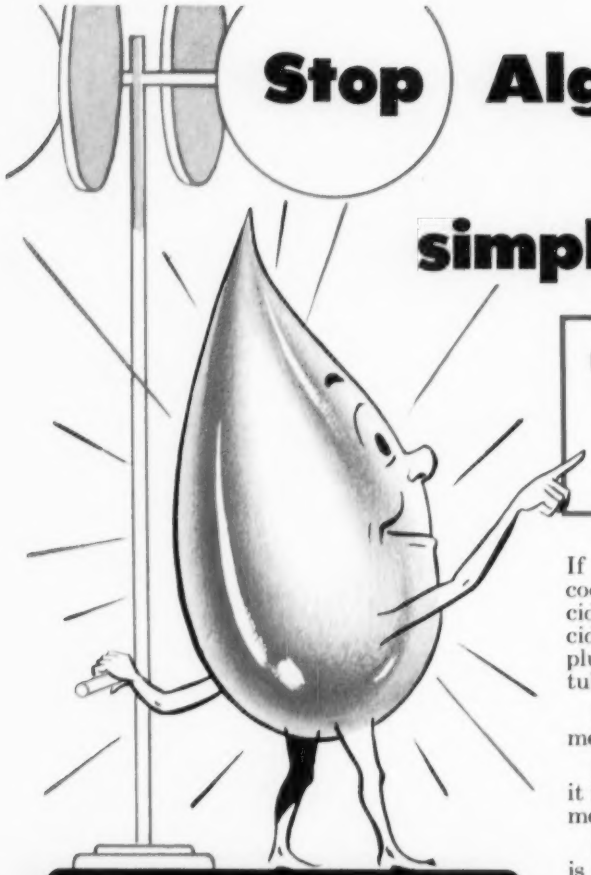
STRETCH OUT RIB DESIGN of Allis-Chalmers motors and see the greater cooling area provided — as much as 43% on many models. Insulation won't fry under normal conditions with deep-rib construction because every rib adds to the heat-dissipating surfaces. The result—moderate overloads can be taken in stride with little fear of burnouts.

As a new machinery component or as replacement, specify Allis-Chalmers. To find out more, contact your nearby A-C district office, distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-C ALLIS CHALMERS

A-4882



Stop Algae Problems *NEW* simple, low-cost way

NEW Allis-Chalmers Algaecide kills all classes of algae and other microscopic organisms in cooling water

If you are troubled by slimes and algae in your cooling tower system, new No. 120 Series Algaecide is the answer. It is the most effective algaecide known. It eliminates such problems as plugged pump strainers, coated heat exchanger tubes, coated slats in cooling towers.

It is easy to introduce into the system by means of a pump, drip feed or manual feed.

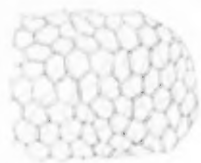
It is safe to handle. Even in concentrated form it is only a mild irritant to skin, eyes and mucous membranes.

Field tests prove that a 5-ppm concentration is toxic to most organisms.

Get complete information on No. 120 Series Algaecide. Call your nearest A-C office, or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin, for Bulletin 28X8434.

Call on ALLIS-CHALMERS for Water Conditioning

As little as 2 ppm has killed all these algae



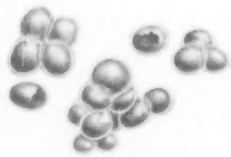
Hydrodictyon

Microcystis

Anabaena

Oocystis

Chlorella



Protococcus

ALLIS-CHALMERS

A-5071

PACKINGS

SIMPLIFY YOUR PACKING PROBLEMS

Use this chart to order the right packing every time

Service	Brine; Water, Cold	Water, Hot	Oil Distillates	Propane and Butane	Oil Up to 400° F.	Oil Over 400° F.	Ammonia	Caustic	Acid
Centrifugal	193	193	413	16193	193	512	193	Weak 136 Strong 293	293
Reciprocating Steam End	101	101	101	101	101	101	101	101	101
Fluid End	16010	16010	16012 151	16012 151 16133	16022 251	16022 512	133	16022 251	293
On Piston	463	453	575	575	...	...	...	...	...
Valve Stem	125	125	413	16193 16133	125	512	125	125	293
Gaskets	9	9	899	899	899	899	9	9	19069 899

Gaskets for: Boilers—Handhole and Manhole 812
Sweetland Press 8797
Tank Car Gaskets { Bolted Type 1771
Screw Type 4773

First style number listed for each condition is best recommendation for that particular service.

TEAR OUT AND SAVE

No longer do you have to wade through the confusion of selecting from hundreds of different packings. The packing recommendations on this chart will pack just about every condition in your refinery.

U. S. Packings come in all the required sizes. Non-standard sizes are usually available on application. The complete line of U. S. Packings is available at any of the selected "U.S." distributors, at any of our 28 District Sales Offices, or write to United States Rubber, Mechanical Goods Division, Rockefeller Center, New York 20, N.Y.

To simplify your packing problems turn the page

Mechanical Goods Division

United States Rubber

For more data on advertised products, use Readers' Service Cards, last page.

US RUBBER PACKINGS

SIMPLIFY YOUR PACKING PROBLEMS

these 6 packings will handle most of your requirements

STYLE 193

STYLE 193—U. S. CENTRIFUGAL PUMP PACKING

For centrifugal pumps, or other rotating or oscillating rods or shafts, handling hot or cold, fresh or salt water, oil, brine, weak acids, caustic solutions and ammonia. Made of long fibre asbestos yarn, plaited square. Each strand thoroughly lubricated and graphited.

STYLE 101—U. S. RAINBESTOS HIGH-PRESSURE ROD AND PLUNGER PACKING

Designed for high-pressure steam, air and gas up to 500° F. Made from selected asbestos cloth, woven from tightly twisted asbestos yarn, with a genuine U. S. Rainbow non-hardening cushion, formed square, and treated with heat-resisting lubricants and preservatives and with a graphite solution.

STYLE 101

STYLE 16010—DUCK AND RUBBER

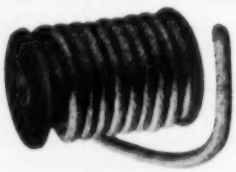
STYLE 16010—U. S. MATCHLESS PACKING

Matchless is the high-pressure packing—will withstand hydraulic pressures as high as 8000 pounds. Self-adjusting, automatic action results in reduced wear and tear on rods and plungers, minimizes friction, keeps down packing costs. For hydraulic equipment, presses, rams, triplex pumps, outside packed pumps, and swivels on rotary drilling rigs.

STYLE 463—U. S. PEERLESS CANVAS PUMP PACKING

For service on inside packed pumps against hot or cold water, and for end rings in hydraulic sets. Made from first quality, closely woven duck laminations cemented together with a high quality rubber friction. Light in weight.

STYLE 463



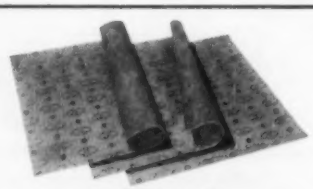
STYLE 125

STYLE 125—U. S. WIZARD ROUND BRAIDED ASBESTOS PACKING

For use in valve stems, reciprocating rods and plungers, against steam, air, hot and cold water, ammonia, oil, chemicals and some acids. Made of long fibre asbestos yarn, braided in round cross-section in the braid-over-braid construction, thoroughly lubricated and graphited throughout.

STYLE 899 (F.O.P.)—U. S. COMPRESSED ASBESTOS SHEET

F.O.P. (Fibre Oil-Proof) is the original oil-proof asbestos fibre high-pressure sheet developed especially for oil industry conditions. Recommended for packing flanges or joints against superheated or saturated steam, air, ammonia, gases, oil, gasoline, water, some acids, alkaline solutions and other chemicals. Ideal for Still Head gaskets. It will not soften, burn, blow or ooze out of a joint, and does not deteriorate with age in stock.



STYLE 899 (F.O.P.)

US RUBBER **Mechanical Goods Division**

United States Rubber

Many extra advantages at no extra cost with this low-pressure pipe covering

Insulating efficiency of ½″ thick Armaglas* Low-Pressure Covering is equal to or better than ¾″ or 1″ thickness of ordinary materials. Lightweight, thin wall design speeds handling and saves space in crowded quarters. Tough glass fiber composition eliminates cracking and crumbling during application. High shrinkage resistance keeps joints tight and neat looking. White vapor barrier jacket needs no further finishing on cold water, hot water, or low-pressure steam lines. Made in molded half sections for pipe and tubing to 12″.

Armaglas is one of the quality products in the complete line of Armstrong Industrial Insulations. Armstrong also offers you a complete contracting service, geared to install these products economically and efficiently.

For complete information on Armaglas, send for free booklet. Booklets on other Armstrong Insulations also supplied on request. Check the ones you want on the coupon below.

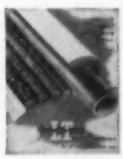
* Trade-Mark. Manufactured for Armstrong by Owens-Corning Fiberglas Corp.

Armstrong

INDUSTRIAL INSULATIONS

☐ Armstrong Armaglas Insulations for Pipes, Tanks, and Vessels

☐ Armstrong Insulcolor®, Weatherproof Coating in Eight Colors



☐ Armstrong LT Cork Covering, a New Type Cold Line Insulation

☐ Armstrong Armaflex**, a New Flexible Insulation for Piping

Armstrong Cork Company
2005 Ream Ave.
Lancaster, Penna.

Please send me the free booklets checked.

Please have an Armstrong representative call. ☐

Name .....

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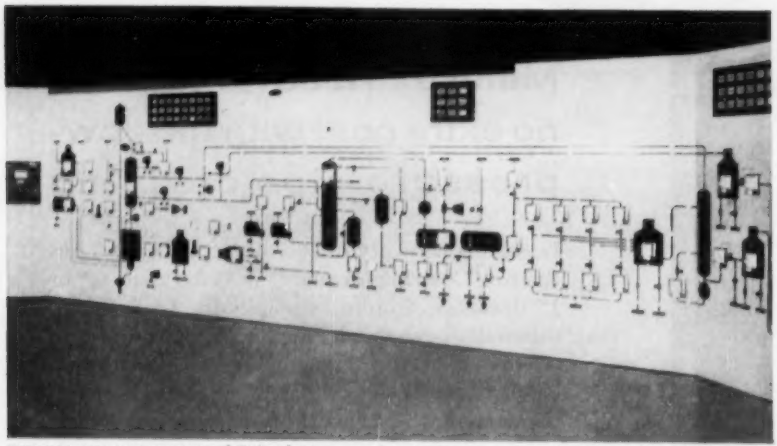
City ..... Zone .... State .....

**TRADE-MARK

BRISTOL'S INSTRUMENTATION

★ *News and information about automatic controlling, recording and telemetering*



TYPICAL GRAPHIC PANEL of Bristol Metagraphic instruments in oil refinery. Panel designed by The Fluor Corporation and built by Panellit Inc.

New design freedom for systems engineers!

A fully flexible plug-in, functional-unit system, Bristol Metagraphic instrumentation is easiest to plan, install, operate and service

A new concept in automatic control and instrumentation, Bristol's Metagraphic instruments are installed as a three part system with transmitters, receivers, and automatic controllers *completely independent of each other except for connection through a universal 3-15 psi pneumatic signal.*

This functionally designed unit system allows a new degree of freedom from pre-installation decisions by the installing and planning engineers. Changes in instrument layout and control actions can be accomplished in an absolute minimum of time and cost.

Transmitters for every variable

Metagraphic transmitters are available for measuring temperature, flow, liquid level, pressure, absolute pressure, differential pressure and mechanical motion.

The transmitter converts the measurement into a universal 3-15 psi signal, proportional to the measured variable, and sends it to an indicating or recording receiver or an automatic controller.

Calibrated simply in terms of 3-15 psi air pressure; Metagraphic receivers and controllers thus are independent of the actual variable being measured by the transmitter and can be used with equal accuracy to indicate, record or control any of the variables that the different transmitters are capable of measuring.

Metagraphic transmitters are available in a variety of ranges and spans—easily field-adjusted—many with over-range protection to 400%. Their high air output (3cfm) means better recording and control in any application.

Choice of 34 automatic controllers

Bristol Metagraphic controllers are available in 34 different models to suit every need. *Yet almost complete interchangeability between models is possible.*

Full-plug-in construction allows easy change of control mode or service, and practically eliminates down time for maintenance.

Controllers may be receiver-, pipe-, or surface-mounted plug-in type or pipe-connected. Remote or integral set-point types (with or without air loading) are available.

Five modes of control action: On-off, adjustable proportional, adjustable proportional plus reset, fixed proportional plus reset, and proportional plus reset plus derivative (rate).

Quick-change receivers in 35 models

With 35 models to choose from, and full plug-in construction available, Bristol's Metagraphic receivers give you unmatched flexibility in operation.

You can change from a recorder to an indicator or vice versa in 10 seconds. If trouble is suspected, the receiver can be replaced to eliminate down time while it's checked in the shop. There's absolutely no interruption of automatic control since the receiver is outside the control loop.

And . . . check these features:

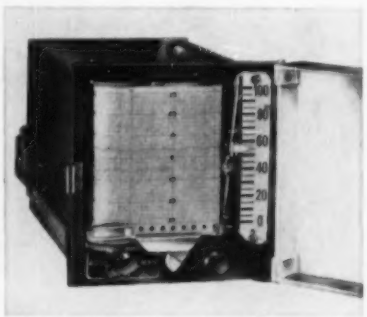
Continuous valve position indication is on same scale as set point. Simply match pointers to achieve "bumpless transfer." No need to read scales.

High-visibility colored fluorescent paints make pointers easy to identify.

Air chart drives are 100% pneumatic (operating from 20 psi supply). No electricity required.

Universal piping manifold can be adapted to any piping system (2-pipe or 4-pipe). No special tools or parts required.

Write for complete data on versatile Bristol Metagraphic instruments for your control, recording or indicating needs.



BRISTOL TWO-PEN metagraphic recording receiver.

Two-pen receiver keeps tabs on four variables

One of the 35 Bristol Metagraphic receiver models available, the two-pen recording receiver records, indicates and controls one measured variable, records one related variable on the same chart and gives a continuous indication of either set point or valve position—whichever is desired.

If valve position is chosen to be continuously indicated, the set point may be indicated at any time by depressing the valve knob. Similarly, if set point is continuously indicated, depressing the knob indicates valve position.

The two-pen recording receiver has the easy readability, compact construction, and plug-in flexibility that characterize all Bristol Metagraphic instruments. It's available with manual-automatic station or six-position transfer valve for cascade control.

Write for complete technical data on this versatile pneumatic recording receiver.

For more data on advertised products, use Readers' Service Cards, last page.

NEWS AND NOTES

instruments from Bristol . . . leaders in human-engineered instrumentation

A-subs hot—but under good control

Construction of the hulls for atomic submarines, Nautilus and Seawolf, probably represents the most massive, elaborate, and radically different welding and hull-rolling job ever attempted.

Built by General Dynamics Corporation, Electric Boat Division, Groton, Connecticut, the subs are constructed from short circular sections (like pipe sections). These sections are welded together around their circumference to form the cigar-shaped hull.

Before welding, the area immediately adjacent to the welds is preheated with induction coils wrapped around adjacent ends of the sections to be welded. Bristol Dynamaster pyrometers precisely control the heat produced by these coils.

When preheated to the proper temperature, the sections are "hull-rolled" while stationary welding machines make the weld at constantly controlled temperatures. After welding is completed, the Dynamaster-controlled induction coils maintain the area around the weld at a uniformly decreasing temperature to insure cooling with maximum strength and toughness.

It takes days to complete the preheating, welding, and cooling for a single hull-section pair. Throughout this period the Dynamaster pyrometers keep the hull temperature at the design value, despite widely varying atmospheric conditions.

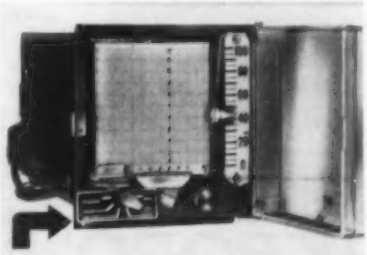
Want to find out more about Bristol Dynamaster pyrometers for your temperature control job, large or small? Write for Bulletin P1245A.

Special receivers simplify cascade control

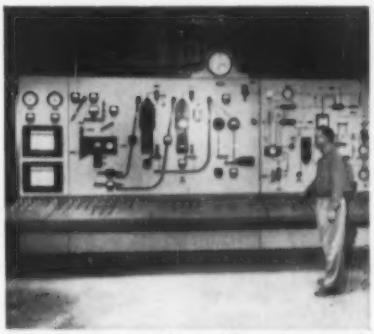
Bristol's Metagraphic receivers for cascade control are offered in a wider variety of models than any similar competitive instrument.

The cascade receiver (or "slave" receiver) is available as a one or two-pen recorder or a one- or two-pointer indicator, or a one-pen, one-pointer model. The two-pen recorder is unique with Bristol. With it, the master controller measurement can be recorded on the same chart as the slave controller record, thus placing both related variables on the same chart. Another, related variable can be recorded in place of the master-controller variable, of course.

One big advantage of Metagraphic cascade control over other similar receivers is the six-position transfer valve, on one knob. Most other models require two knobs, and pointers on two scales in order to achieve bumpless transfer. With Bristol's six-position model you just match pointers *on the same scale*, and switch over.



SIX-POSITION TRANSFER VALVE on one knob for cascade control.



GRAPHIC PANEL at Central Soya Company's plant at Chattanooga, Tennessee.

Bristol instruments help process Soy Beans

Centralized control of a soy-bean oil extraction plant is the function of this graphic instrument panel, installed at the Chattanooga, Tennessee, plant of the Central Soya Company.

Multiple-point Bristol Dynamaster and Metagraphic recorders monitor temperatures and pressures throughout the process, as well as plant power consumption and steam pressure. Ammeters on the panel show current drawn by equipment and conveyor motors. Control switches and running lights are located on the desk surface at front of panel.

One compelling advantage of this graphic panel instrumentation system is that it safely and conveniently shows both management and operating personnel the whole operation. Quality control is greatly facilitated; system upsets may be analyzed and corrected before the final product is affected. This over-all picture is otherwise very difficult to get since the process occupies a building four stories in height that has floor levels made of steel gratings.

OUR ENGINEERS . . .

will be glad to discuss your specific instrumentation or control problem with you. Or, write for complete technical data on any of the instruments mentioned on these pages. The Bristol Company, 111 Bristol Road, Waterbury, Conn.

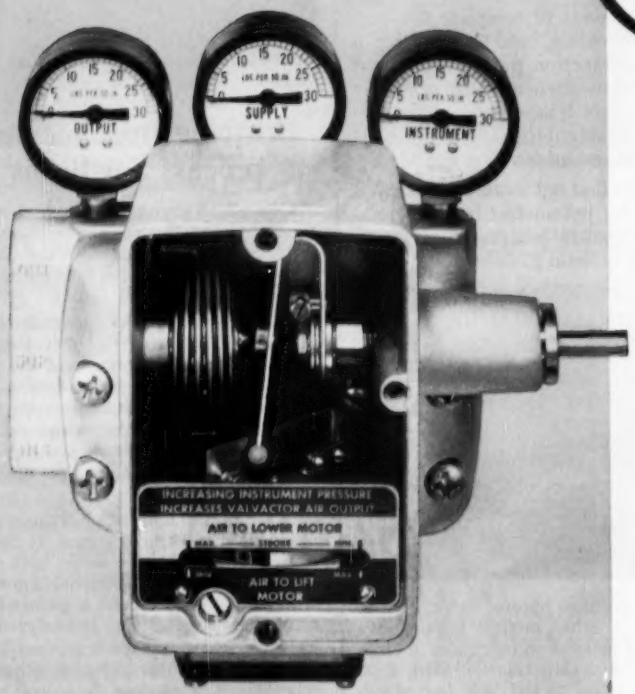
6.21

WHAT'S NEWS AT BRISTOL . . . WHAT'S NEWS AT BRISTOL . . .

NEW!

MOST UNIVERSALLY ADAPTABLE VALVE POSITIONER ON THE MARKET!

...the Foxboro Type C VERNIER VALVACTOR*



The Type C Valvactor's distinctive motion-balance principle of stem positioning eliminates loading effects of heavy fixed-stroke actuating springs. Note compactness — the simplest mechanical design of any valve positioner.

**Trademark of a precision valve positioner made by The Foxboro Co.*

Unique Flexibility Easily reversible in seconds. Sequencing by two simple adjustments.

Super Response Full air-pressure output to diaphragm motor on signal air-pressure change as small as ½ of 1% of signal span.

Extra Speed New, high capacity relay provides high speed positioning action.

Positive Positioning Direct, motion-balance feed-back assures instantaneous, pin-point positioning.

Now there's a positive-action, super-precision valve positioner that you can easily adapt to *any* diaphragm motor application — without exchange of parts! It's the Foxboro Type C Vernier Valvactor with unique motion-feedback.

The Type C Valvactor has a master setting disc which provides easy change of action as required by the control system, as well as easy reversal of Valvactor action for air-to-open or air-to-close control valves. Adjusting for limited stem travel is equally simple ... sequencing of several valves is a cinch!

The Valvactor is the ideal solution to such problems as stem friction, plug friction, valve motor and transmission line lag, and extreme process line pressure changes. And it requires practically no maintenance! Available with 3-gauge and by-pass manifold, or plain manifold. Write for full details.

The Foxboro Company, 745 Neponset Ave., Foxboro, Mass., U.S.A.

FOXBORO
REG. U.S. PAT. OFF.

VALVE POSITIONERS

For more data on advertised products, use Readers' Service Cards, last page.

One man in this midget fire truck puts out the fire. Rockwood equipment makes it possible!

"Mighty Mite" puts out fire in 45 seconds

"Mighty Mite" is a swift fire fighter!

It was just a test, but the fire was real. Fuel in a pit under the tank car was set on fire. Fuel poured on top of the car from pipes was also ignited. The blaze was given a minute's start.

"Mighty Mite", loaded with Rockwood fire fighting equipment, went into action. The blaze was choked off in 45 seconds by Rockwood WaterFOG from Rockwood's Remote Manual Control Turret!

Rockwood equipment makes the small truck a big fire fighter. The Turret Nozzle does many jobs—discharges solid water stream, WaterFOG, FogFOAM, solid FOAM stream, "Wet" solid water stream, and "Wet" WaterFOG!

For complete details on this powerful Rockwood equipment send coupon below.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

Distributors in all principal cities

"Mighty Mite's" equipment includes: 4 stage centrifugal pump, 200-gallon booster tank, Rockwood Dual Suction Proportioning System for FOAM and "Wet", Rockwood Remote Manual Control Turret controlled from within the cab, Rockwood Ground Sweep Nozzles, Rockwood Remote Control Ball Valves, 2 hose reels with 200 feet of high pressure hose with new Rockwood High Pressure Handline Nozzle on each reel.

ROCKWOOD SPRINKLER COMPANY
Portable Fire Protection Division
1092 Harlow Street
Worcester 5, Mass.

Please send me your illustrated booklet on Rockwood fire fighting products.

Name .....

Title .....

Company .....

Street ..... *City* .....

Zone ..... *State* .....

For more data on advertised products, use Readers' Service Cards, last page.

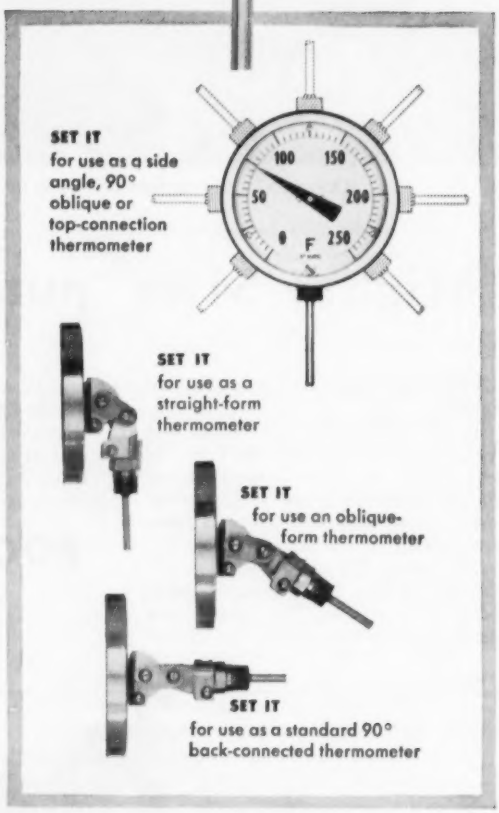
"Every Angle" Design Maxivision® Accuracy Bi-Metal Actuation

Now...all 3 in one 'American' Thermometer

Only this new American Thermometer* gives you the three features most demanded in a dial thermometer. The "Every Angle" design allows you to install this thermometer *anywhere* . . . then angle it in the direction that provides easiest reading. The anti-parallax Maxivision dial guarantees the surest, sharpest, easiest reading. Graduations are carried on a raised ring, set close to the cover glass, with an index-type, functional pointer set at the same level. The result – no perspective effect – parallax error practically eliminated. Finally, bi-metal actuation insures high sensitivity, economy, and surety of operation.

Install the new American "Every Angle" Bi-Metal Dial Thermometer anywhere – inside or out. Its climate-proof case defies any weather condition. The full use of these thermometers in any process plant makes possible temperature readings with the same ease and facility of those of a pressure gauge. Write today for complete information. Ask for Bulletin 148.

*Pat. App. For



SPECIFICATIONS

5-Inch Type 5-6060 American "Every Angle" Bi-Metal Dial Thermometer

Temperature Ranges: From minus 80° to plus 1000° F. Accuracy within 1% of range. *Dial Size:* 5". Scale approximately 10½" long. *Bi-Metal Coil:* Low mass, with single helix close to inside wall of stem assures high sensitivity. Silicone fluid dampens vibration, accelerates transfer, speeds response. *Case:* Stainless steel. *Bezel:* Threaded to case. *Front:* Clear, extra-heavy glass set in channeled gasket to seal case. *Pointer:* Functional type, adjustable from front. *Stem:* Lengths – 4" to 24", 18-8 stainless steel. All joints welded. *Connection:* Fixed, ½" NPT. *Separable Sockets:* Available in all materials and sizes normally required.

PHONE your Industrial Supply Distributor for experienced attention to your needs. He is always ready to help you ward off costly shut-downs through fast delivery from local stocks.

AMERICAN INDUSTRIAL INSTRUMENTS

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

Strong • Safe • Tough

It really pays to "safe-tread" with MULTIGRIP FLOOR PLATE

USS MULTIGRIP FLOOR PLATE is an ideal plant floor covering. It's made of rugged steel with evenly-spaced, flat-topped risers that give traction to feet and wheels. Oil or grease *cannot* soak into Multigrip and a hose or broom keeps it clean.

Whether it's on ramps, stairs, platforms, aisles or entire floor areas, Multigrip stands up for years with hardly a sign of wear. It may be bent or formed when necessary, is easily welded and simple to install. Multigrip Floor Plate is available in large plates to minimize installation waste. Pick out the danger areas in *your* plant, then install Multigrip Floor Plate to reduce both hazards and maintenance.

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, CHICAGO
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

multigrip

FLOOR PLATE

USS

Sold by leading distributors from coast to coast

UNITED STATES STEEL

He'll tell you they don't leak

. . . here's why

3 seals prevent shank and gland leaks on OIC lubricated plug valves.

1. Concentric grooves form a *labyrinth seal.*
2. Gland liner also retains an *O-ring*—a second seal.
3. *Resilient packing* forms a third seal . . . is completely isolated from all moving parts.

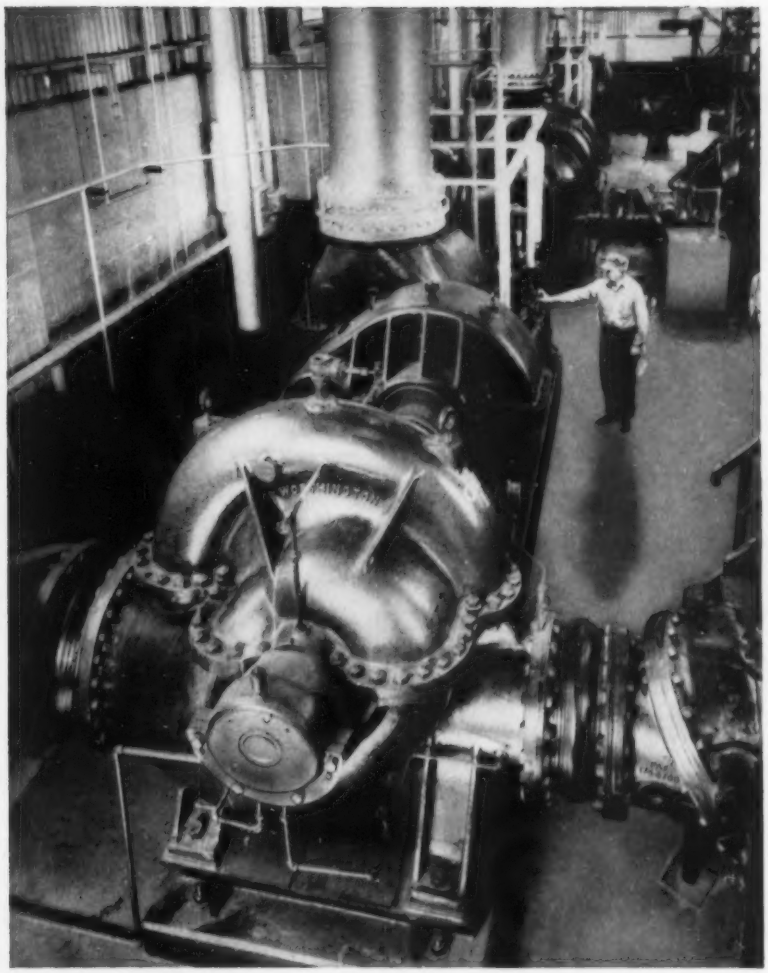
This *exclusive* OIC lubricated plug valve design not only prevents shank leaks, it also helps retain gland adjustment longer. That's why OIC plug valves rate high with maintenance men. For details write for the new OIC bulletin, Form No. 1003-R.

THE OHIO INJECTOR COMPANY
WADSWORTH • OHIO

OIC VALVES

FORGED & CAST STEEL, LUBRICATED PLUG, BRONZE & IRON VALVES

For more data on advertised products, use Readers' Service Cards, last page.



Three Worthington horizontal centrifugal pumps at Gulf Coast refinery.

Gulf Coast refinery picks Worthington horizontal centrifugal water pumps

In oil refining operations you've got two strikes against you if you can't count on a dependable general water supply.

You need water for cooling towers, general service, engine and compressor cooling, heat exchangers and condensers. And water must be available 24 hours a day to eliminate costly down-time.

That's why a Gulf Coast oil company picked three Worthington turbine-driven horizontal centrifugal pumps *(above)* for water in their Texas refinery. These units operate continuously at rated capacity, head and efficiency.

The easy accessibility for inspection and maintenance, the 24-hour dependability and sustained performance of these pumps reflect Worthington's experience with refinery pumping problems.

Why a horizontal pump?

Here are five big reasons for installing a Worthington horizontal centrifugal pump:

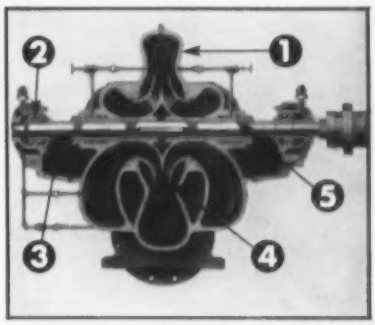
1. **Casing** — horizontally split. Upper half lifts off to allow inspection and maintenance.

2. **Bearings** — double-row ball bearings are easily accessible for servicing and replacement. Location prevents contamination from water being pumped.

3. **Shaft** — easily arranged for dual drive. Shaft may be extended opposite main drive source to accommodate any standby prime mover.

4. **Symmetrical impeller** — balanced axial forces mean negligible thrust loads for low wear, long life. High initial and sustained efficiency.

5. **Stuffing boxes** — under suction pressure and fitted with renewable shaft sleeves.



Horizontal centrifugal pump (cutaway view).

There's a Worthington horizontal centrifugal pump for every purpose. Available with casing, impeller, shaft, shaft sleeve, and wearing rings in bronze, iron or alloys for various water conditions — with standard water-sealed stuffing boxes or mechanical seals. Get all the facts on Worthington horizontal centrifugal pumps for your application — jot down your requirements on your letterhead and we'll send you bulletins on suitable pumps promptly. Write Worthington Corporation, Section C.5.1C, Harrison, N.J.

C.5.1C

WORTHINGTON

THE WORLD'S BROADEST LINE ASSURES YOU THE RIGHT PUMP FOR EVERY JOB

CENTRIFUGAL • ROTARY • STEAM • POWER • VERTICAL TURBINE

POWELL

Lubricated Plug

VALVES

Powell Lubricated Plug Valves maintain our 110-year tradition of quality and precision. Only the finest available materials are used. And painstaking quality control is rigidly enforced through each and every step of manufacture.

Features include quick and positive operation—just a quarter-turn to open or close. Lubricant grooves surrounding each port provide a positive seal when the valve is closed. In an open position, seating surfaces are not exposed.

Valve users who want one source of supply for lubricated plug as well as all types of bronze, iron, steel and corrosion-resistant valves will want full details on Powell Lubricated Plug Valves.

Write us immediately for the new PV-4 Catalog on Powell Lubricated Plug Valves.

Available in Steel and Semi-Steel through distributors in principal cities. If none is located near you—or if you need help on valve problems—write direct to

The Wm. Powell Company, Cincinnati 22, Ohio . . . . . 110th YEAR

PERFORMANCE PV VERIFIED

The source of supply for all valve needs!

BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES

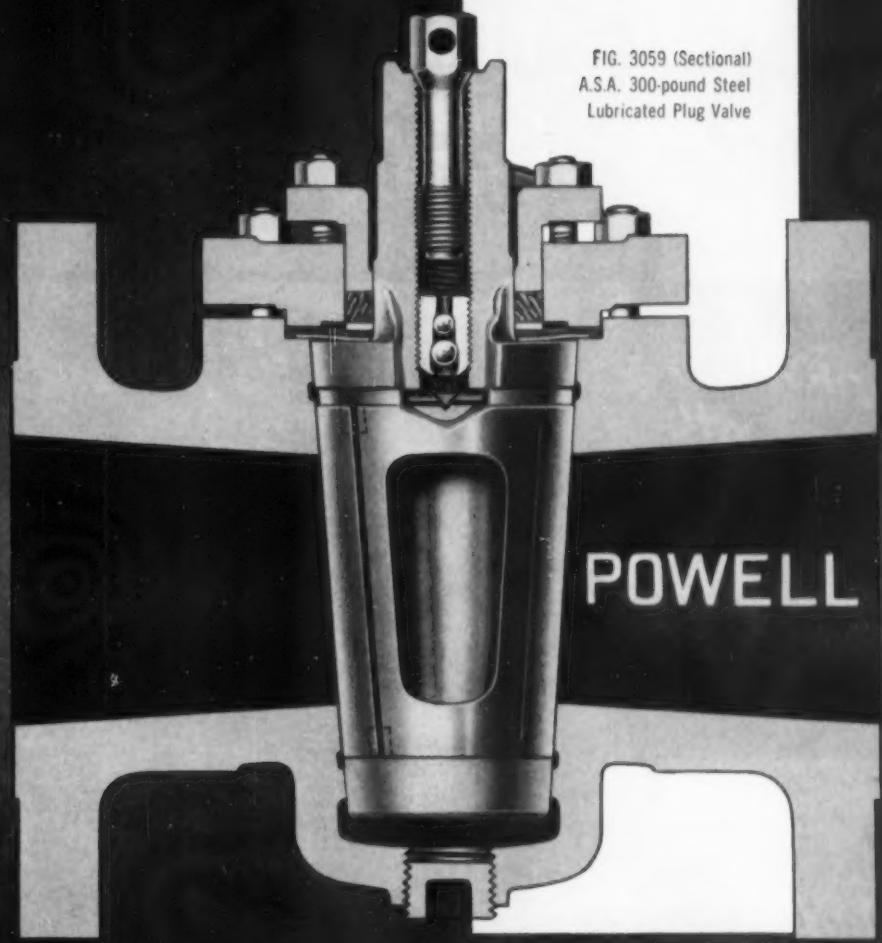


FIG. 3059 (Sectional)
A.S.A. 300-pound Steel
Lubricated Plug Valve

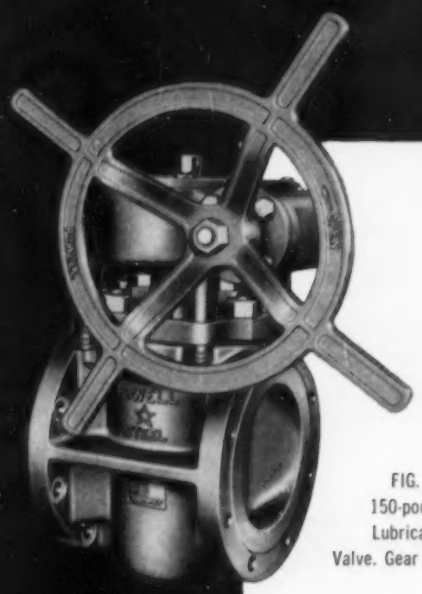


FIG. 1559G—
150-pound Steel
Lubricated Plug
Valve. Gear operated

FIG. 2200—175-pound W.O.G.
Semi-Steel Lubricated Plug Valve

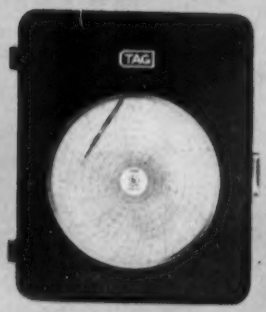
For more data on advertised products, use Readers' Service Cards, last page.

to regulate and record—

TEMPERATURE.. PRESSURE.. VACUUM..TIME

mechanical instruments by

WESTON



RECORDING INSTRUMENTS . . . in 9", 10" and 12" chart sizes — single and multipen — for all requirements.

RECORDING CONTROLLERS . . . handle temperatures from −325°F to 1000°F—vacuum to 30" mercury — pressures to 7500 psi or higher.

TIME CONTROLLERS . . . make any semiautomatic retort control system fully automatic. Available in both standard and special forms.

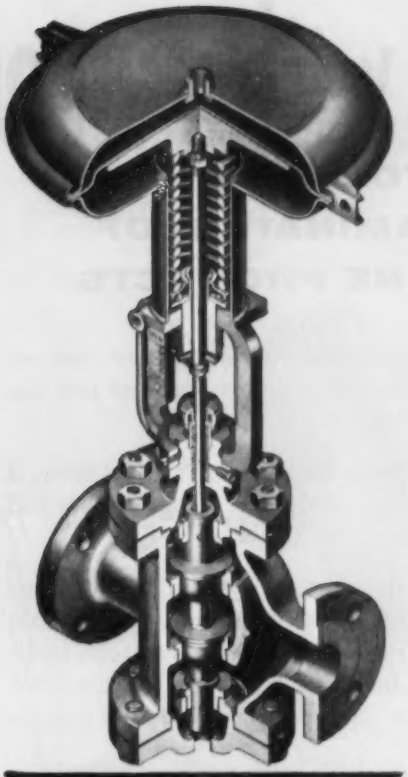
INDICATING CONTROLLERS . . . accurately regulate temperature, vacuum, pressure and indicate on direct-reading scale.

DIAL THERMOMETERS (remote reading) . . . furnished with mercury, gas, or vapor pressure actuations. Flush or wall mounting. Indicate low as −325°F., high as 1000°F.

Just Published!

Just published . . . the new catalog M2A which fully illustrates and describes the comprehensive line of WESTON mechanical instruments, noted for their long-time accuracy and dependability. Send for your copy today; or ask your local Weston representative for help on any measurement or control problem involving temperature, vacuum, pressure. Weston Electrical Instrument Corporation, 614 Frelinghuysen Avenue, Newark 5, New Jersey, *a subsidiary of Daystrom Incorporated.*

WESTON *Instruments*



the valve that LIKES TO BE COMPARED

Is a valve positioner always required?

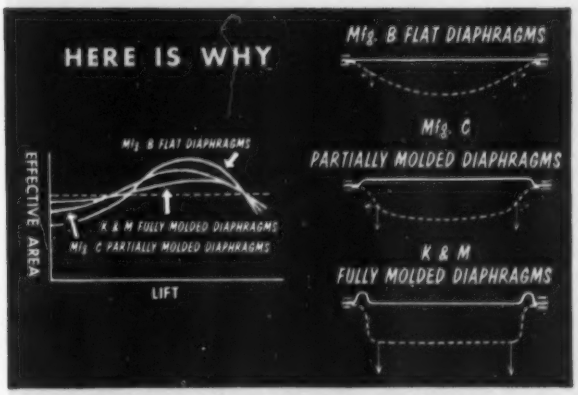
K & M provides 20-40% less positioning error. Often the need for a valve positioner is eliminated . . . because the K & M *fully* molded diaphragm gives the most constant effective diaphragm area.

K & M precision positioning also derives from long stem travel . . . lift that equals or exceeds any comparable valve . . . plus the highest power factor in the industry.

Behind it all lies one fact: K & M Control Valves are not *adapted* to high lift, they are *designed* for it. Throughout the entire range of valve travel . . . positioning is accurate and undistorted . . . control increments are finer with minimized positioning error.

Write for the K & M Valve Data Catalog, Bulletin CV-53.

77th Anniversary . . . Oldest U. S. Pressure and Level Control Valve Manufacturer



With K & M *fully molded* diaphragms, virtually all components of force are vertical. Added to this, K & M gives the highest power factor (diaphragm area x lift) for precise valve positioning.

diaphragm control valves

KIELEY & MUELLER, INC.

64 GENUNG STREET, MIDDLETOWN, NEW YORK

K&M

For more data on advertised products, use Readers' Service Cards, last page.

It's Easy with UNICOR®

TO AVOID CONTAMINATION OF PIPE LINE PRODUCTS

You get complete freedom from product contamination and at the same time economical protection for your pipe line when you use UOP UNICOR.

UNICOR is added only at the points of product entry, is distributed uniformly over the entire internal surface and effects 100% protection.

UNICOR is inexpensive to use, too. Actually, only one or two molecules of UNICOR are required for every 1,000,000 molecules of gasoline. This makes UNICOR's cost only about $0.0005/bbl. of pipe line product. There are additional savings, too, in reduced scraper-cleaning and filter replacement costs.

Our technical staff will be glad to assist you in the design, installation and operation of a UNICOR system of protection. Write us for information and samples.

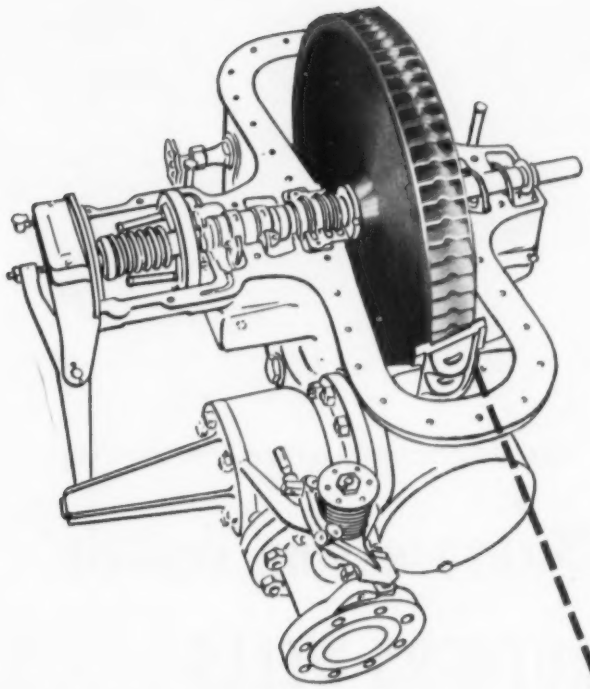
PRODUCTS DEPARTMENT

UNIVERSAL OIL PRODUCTS COMPANY

UOP®

30 ALGONQUIN ROAD
DES PLAINES, ILLINOIS, U. S. A.

Work Horse of Industry..since 1906



The Terry Steam Turbine Company was incorporated in 1906 to manufacture *a workable and efficient prime mover that would operate with minimum maintenance.* This prime mover was the solid-wheel turbine, which had been invented by Edward Clinton Terry a few years before.

Although maintenance practice has improved vastly since then, the demand for the turbine has multiplied many times. *Rising maintenance costs have actually increased the need for trouble-free operation.*

Today, there are more Terry solid-wheel turbines in operation, and there are more built each year, than ever before. The explanation is simple.

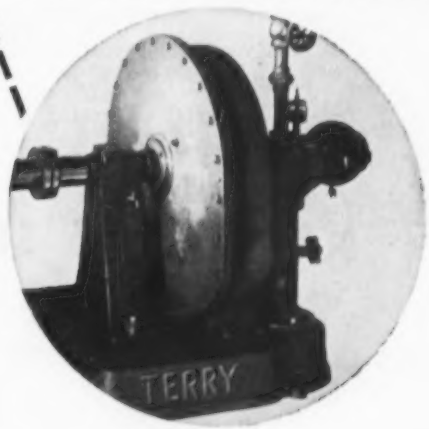
Here is a turbine with a virtually indestructible wheel. Made of a single forging of special composition steel, there are no separate parts to loosen or work out. As the only function of the blades is to form a series of pockets, any wear which may occur does not materially affect horsepower or efficiency.

Blades will not foul. They have large clearances and are further protected by the projecting rims at the sides of the wheel. As the side clearances are also very large, end play can do no harm.

These are a few of the reasons why the Terry solid wheel turbine has been the *work horse of industry — since 1906.* For the full story, send for a copy of Bulletin S-116.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

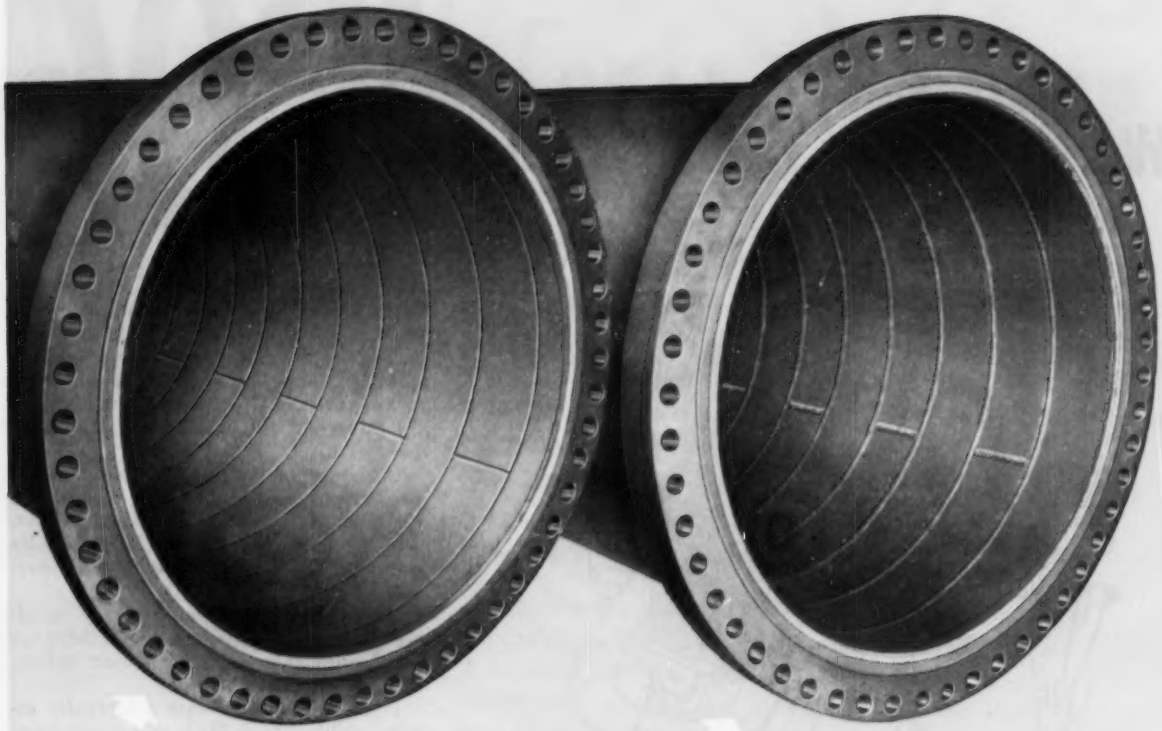
TERRY



1906 was the year this turbine was built in Terry's plant. It is believed to be one of the first small direct-connected turbines built for commercial use in the United States.

TT-1203

For more data on advertised products, use Readers' Service Cards, last page.



Lining Fitted—Before Welding *Vessel Completely Lined—After Welding*

For Special *Lined* Processing Vessels

Come to STRUTHERS WELLS

LINING processing vessels of all kinds for chemical plants and refineries is another service in which Struthers Wells specializes. Years of engineering experience and extensive fabricating facilities enable us to build lined vessels that meet all codes and requirements.

The vessel illustrated is Inconel-lined, 36″ I.D. x 43′ high. Working pressure is 600 lbs. Lining is welded to outer wall to become an integral part of the processing vessel.

Vessels can be furnished lined with titanium, stainless steel, nickel, silver, hastelloy and other weldable metals to suit your applications.

Struthers Wells

STRUTHERS WELLS CORPORATION

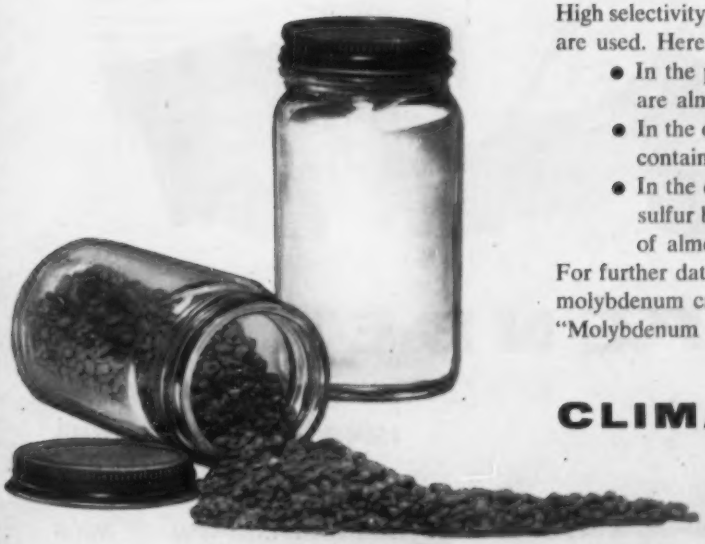
TITUSVILLE, PA.

Plants at Titusville, Pa. and Warren, Pa.

Offices in Principal Cities

For more data on advertised products, use Readers' Service Cards, last page.

Moly catalysts are selective



High selectivity is provided in reactions where molybdenum catalysts are used. Here are three examples:

- In the production of formaldehyde from methanol, yields are almost quantitative.
- In the oxidation of aliphatics to maleic anhydride, the product contains no by-product maleic or fumaric acid.
- In the desulfurization of petroleum stocks, the carbon to sulfur bond is selectively hydrogenated with recoveries of almost 100%.

For further data on these reactions as well as many others using molybdenum catalysts, write Dept. 25 for our bulletin "Molybdenum Catalysts for Industrial Processes."

CLIMAX MOLYBDENUM

500 Fifth Avenue, New York 36, N. Y.

GAGE VALVES

INJECTORS

CYCLING JET PUMPS

PENBERTHY PRODUCTS FOR PETROLEUM . . .

MEASURE • MIX • PUMP • WASH • EXHAUST • AGITATE • COMPRESS • ATOMIZE
CIRCULATE • AERATE • INJECT • CONDENSE • EXTRACT • AMONG OTHER USES

SUMP PUMPS

● Simplifying systems, saving time and money, guaranteeing accuracy — Penberthy products serve the petroleum industry directly and as components of equipment. Penberthy is equipped and staffed to engineer and produce dependable products. We'll be glad to send you catalogs and literature detailing our products and services. You are almost certain to find one or more ways we can contribute to your operations.

WATER HEATERS

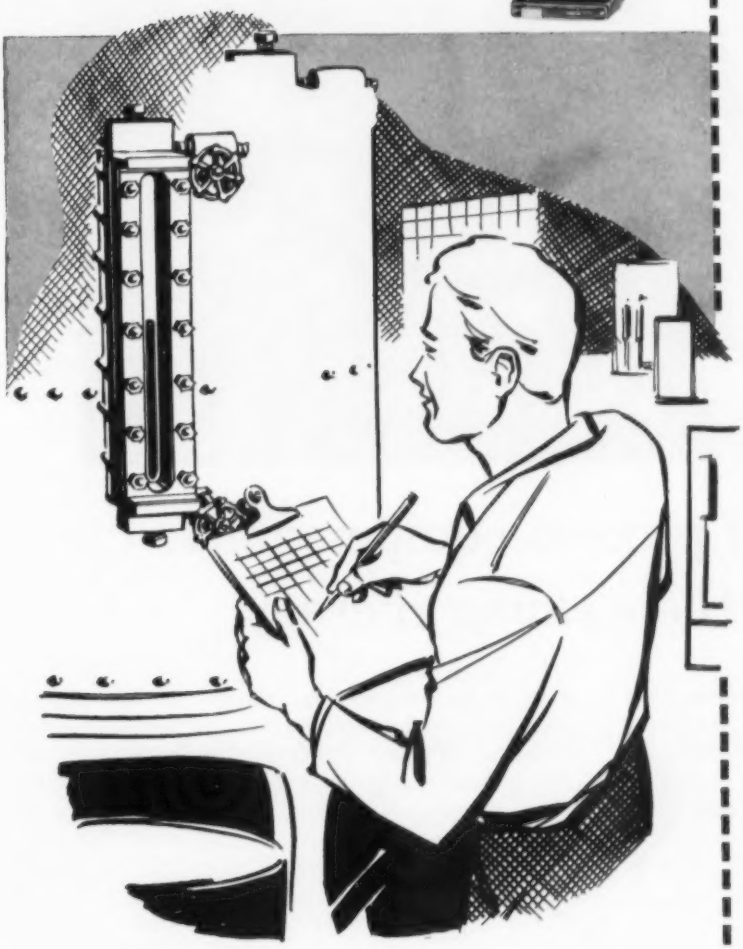
PENBERTHY

DIVISION OF BUFFALO

1242 Holden Avenue

LIQUID LEVEL GAGES

JET PUMPS
(Ejectors, Eductors, Exhausters, Syphons)



Penberthy Gages feature, as standard, the exclusive "Raised Face" to facilitate cleaning and replacement . . . assuring perfect alignment of frame with glass and gasket. They are accurate, rugged and reliable. Available in standard or special designs, sizes and materials. The line includes: Reflex, Transparent, High Pressure, Frost-Free, Heating Tube and Heating Chamber, Welding Pad, Large Chamber and Inclined Gages as well as Explosion-Proof Illuminators.

Penberthy Gage Valves, with exclusive "Floating Shank", save 50% and more on installation costs alone . . . eliminate dangerous strains common to forced installations. The line includes: Tubular and Threaded gage valves. Jacketed gage valves, Instrument valves. Wire glass, plate glass and sheet metal guard protectors.

Penberthy Ejectors are available in bronze, iron, stainless steel, plastic and other materials . . . in standard or made-to-order designs. They provide a simple, efficient means of handling liquids, gases, solids in suspension and even dry materials. Nothing to get out of order, low cost, small size, practically noiseless.

Penberthy Cycling Jet Pumps are gas, steam, or air operated with a minimum of moving parts. Superior for injecting chemicals into vessels or lines, transferring fluids and for pumping operations in hazardous locations.

Penberthy Water Heaters utilize steam to heat water or any other liquid to any temperature up to 212°F. High grade bronze construction. Compact. Efficient.

Penberthy Sump Pumps are available in a variety of sizes and capacities, bronze construction, automatic-electric, standard, submersible and explosion-proof.

INJECTOR CO.

ECLIPSE CORPORATION

Detroit 2, Michigan

For more data on advertised products, use Readers' Service Cards, last page.

The proof of process equipment....
....is in the *welding* thereof

.... and Vulcan welding is top quality—distinguished by proven skill, modern methods, technical supervision and close inspection (including x-ray). Towers, exchangers, kettles, condensers, piping — all depend on skillful, pressure-tested welds, carefully designed in accordance with your exact process requirements.

This is what you get when you specify Vulcan in your equipment ordering. Vulcan's welding department has gained recognition for its progressive welding methods and proven ability on difficult jobs. Why not obtain these benefits for your company? For quality-built pressure vessels, you can't do better than to order from Vulcan.

We invite your next inquiry.

VULCAN MANUFACTURING DIVISION

The VULCAN COPPER & SUPPLY CO., *General Offices and Plant,* CINCINNATI 2, OHIO

BOSTON DENVER HOUSTON SAN FRANCISCO

VICKERS VULCAN PROCESS ENGINEERING CO., LTD., MONTREAL, CANADA

DIVISIONS OF THE VULCAN COPPER & SUPPLY CO.:

VULCAN ENGINEERING DIVISION • VULCAN MANUFACTURING DIVISION • VULCAN CONSTRUCTION DIVISION

For more data on advertised products, use Readers' Service Cards, last page.

BIRDIE... thanks to brick!

And impossible *without* brick. You would have no rubber for the ball... no steel for the clubs. You would have no mower to trim the fairways and clip the greens. And no clubhouse.

Everything made... everything that moves... owes its very existence to refractory brick... refractory brick that contains and controls the many flames of industry. Brick in infinite variety of shape and composition. There could be no industry were it not for brick.

And General Refractories, to provide the complete refractory service that industry needs, employs the world's largest, most-modern refractories research laboratory and 66 mines and manufacturing plants both here and abroad.

A Complete Refractories Service

GENERAL REFRACTORIES COMPANY
Philadelphia 2

A COMPLETE REFRACTORIES SERVICE FOR THE PETROLEUM INDUSTRY

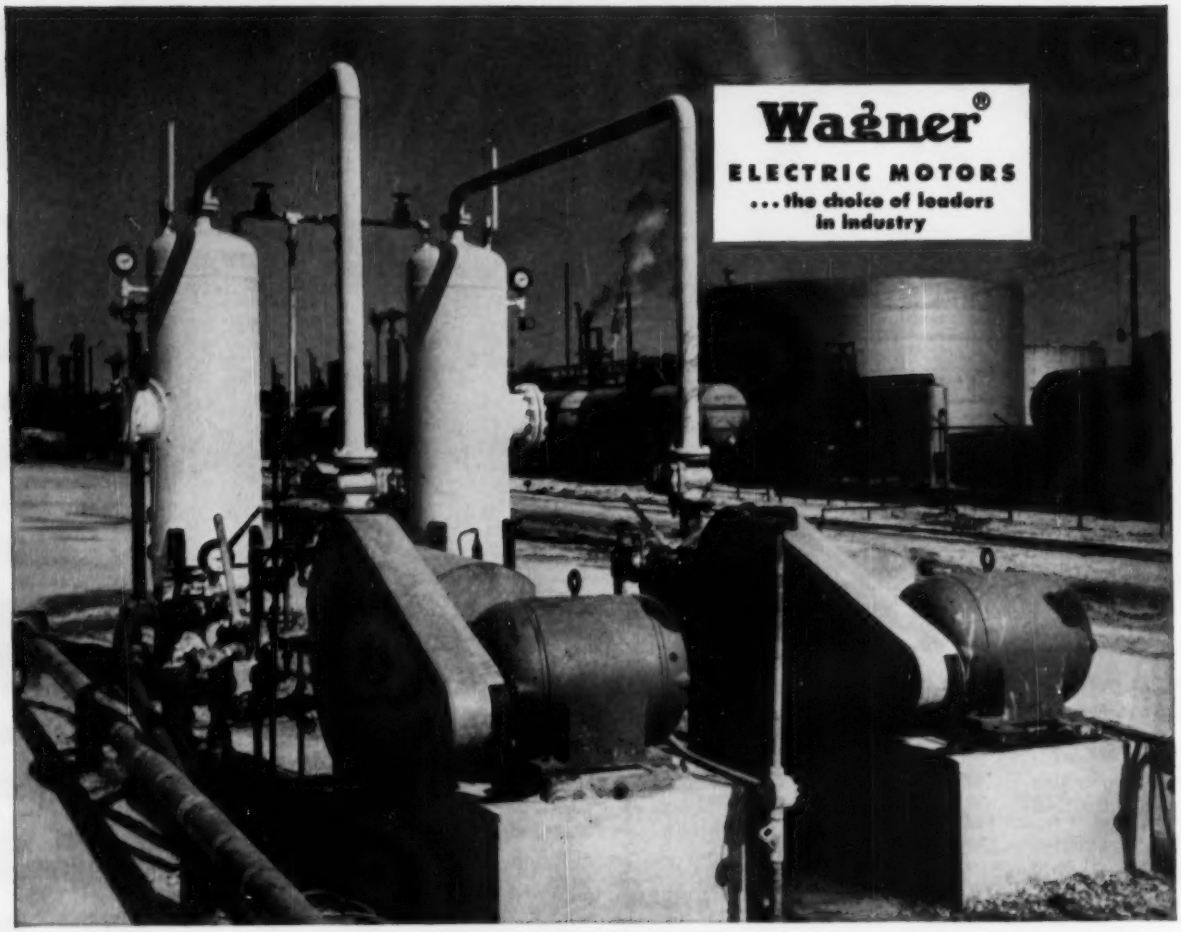
LITECAST 50—A hydraulic-setting insulating castable refractory material, having a density of approximately 50 lbs. per cubic foot. Its extreme light weight and exceptionally low thermal conductivity make it an efficient and economical heat insulator. Recommended for vessel linings and backing for brickwork for other heavier castable refractory materials.

HIGH-STRENGTH BRIK-CAST—A hydraulic-setting castable refractory material unique in that it contains more bonding agent, which results in a product more resistant to the physical actions of impact, erosion, and load bearing. Used extensively for lining regenerator chambers and catalyst lines in catalytic cracking units.

LITECAST 50-M—A 50-pound density insulating castable, having a high degree of purity, used as a liner in vessels and lines where atmospheres must be controlled, or contamination of internals must be avoided. LITECAST 50-M may be applied in the same manner as standard hydraulic-setting castables.

BRIK-CAST 3000—A hydraulic-setting castable refractory material, composed of clays and bonding agents having the highest purity, resulting in a product with a high operating temperature (3000° F.), and resistance to reducing atmosphere in carbon monoxide attack. Recommended for sulphur burner chambers and other vessels operating above normal cracking and reforming temperatures.

GENERAL REFRACTORIES



Protected against explosion

WAGNER JP MOTORS

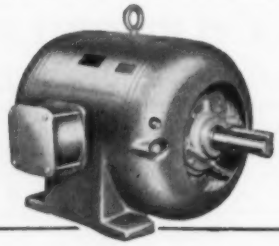
A single spark in a hazardous atmosphere can mean the end of refinery production . . . to say nothing of possible loss of life and millions of dollars in damage from fire and explosion.

Wagner Type JP Explosion-Proof Motors are expressly built for applications in hazardous atmospheres. They're perfect for the job . . . that's why they're the time-tested favorites of the petroleum industry—in pumping stations and in refineries. They are approved by Underwriters' Laboratories for Class 1 Group D hazardous locations. These motors are available in a complete range of ratings through 250 hp, normal torque and high torque.

In addition to these explosion-proof motors, Wagner also maufactures a line of drip-proof 40°C. polyphase motors, in ratings through 75 hp, especially designed for the continuous outdoor service demanded by oil well pumping applications. High power factor type capacitor oil well pumping motors are available for use where single-phase motors are required.

Write for Bulletin MU-132 on Cast Iron Frame Motors and for Bulletin MU-137 on Oil Well Pumping Motors. Thirty-two branch offices are ready to assist you in any motor application problem.

This Wagner Type JP Explosion-Proof, cast iron motor, with frames and end-plates of cast iron, is suitable for indoor or outdoor use and for installations where corrosion is a problem . . . as well as for general applications.



Wagner Electric Corporation
EST. 1891

Wagner Electric Corporation
6458 Plymouth Ave., St. Louis 14, Mo., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

M56-3

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS–AIR AND HYDRAULIC

METALS PROCESSING

by Curtiss-Wright gives you better quality high alloy castings, forgings, extrusions

. . . and more of them

A wide variety of high precision metal parts – engineered to the needs of the nation's industries for products that serve you in many ways–are in quantity production today at the Curtiss-Wright Metals Processing Division, Buffalo, N. Y. Here experienced metallurgists work with the latest and most advanced forging and machining techniques . . . centrifugal, sand and ceramic casting equipment . . . the world's largest horizontal steel extrusion press, capable of a 24-million pound "squeeze" . . . and with other improved equipment and methods . . . processing stainless and other steels, titanium, and non-ferrous metals into performance-proven parts . . . faster, more economically.

Offering higher precision, higher production . . . improved techniques with unusual and intricate shapes, to higher specifications . . . products of every description, from jet engine blades to the shredder rings for garbage disposal units . . . Curtiss-Wright Metals Processing has become a prime source for American industry.

If you are a manufacturer, write for facts outlining your specific application today. *Branches coast to coast.*

METALS PROCESSING DIVISION
CURTISS-WRIGHT CW
CORPORATION • BUFFALO, N. Y.

YOUNG MEN! JOIN THE U. S. AIR FORCE

Investigate Career Opportunities At Your Nearest Recruiting Office

For more data on advertised products, use Readers' Service Cards, last page.

. . . there's enough difference to make ALL the difference

Every single finished Scovill Heat Exchanger Tube is subjected to a 1,000-lb. hydrostatic pressure test and an 80-lb. air pressure test under the eyes of experienced inspectors. Very seldom does a tube fail at this point; yet this and other final inspections for tube perfection are always rigidly maintained.

Before Scovill Heat Exchanger Tubes reach these final inspection benches, specialized production methods and controls have already assured their inherent uniformity in alloy composition . . . with soundness in metal structure . . . and dense, smooth surfaces, free from defects. Scovill safeguards assure delivery to customers of tubes in top physical condition . . . an essential to dependable heat exchanger service.

Scovill Technical Service stands ready to help you select the correct tube alloys for your applications, with recommendations based on most comprehensive experience records.

Scovill Manufacturing Company, Mill Products Division,
99 Mill Street, Waterbury 20, Connecticut. Phone: Plaza 4-1171.

SCOVILL HEAT EXCHANGER TUBE

Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Muntz Metal • Naval Brass • Red Brass, 85% • Deoxidized Copper
Arsenical Copper • Copper Nickel, 10% & 20% • Cupro Nickel, 30% • Aluminum Brass • Aluminum Bronze, 5% • Duplex Tube

116C56

Attapulgus Clay says **STOP!**

to
Platinum Catalyst
poisons

Attapulgus Clay keeps strict watch over your catalytic reforming feed stocks, protects you against losses caused by catalyst poisoning. It does this by effectively reducing the detrimental constituents that temporarily (sometimes permanently) foul the catalyst.

Here are the troublemakers (some need only be present at 10 parts per billion) that Attapulgus Clay removes from the stream: Arsenic—either present in the crude, or picked up from equipment; Tetraethyl Lead—from refinery cross-contamination; Alkyl Sulfur compounds; Nitrogen—from crude or other sources.

Setting up this effective clay treatment safeguard can be accomplished at a surprisingly low investment—one that pays out promptly in terms of the most favorable production rate.

This is another solid example of how M&C products keep growing in value to refiners. There's always a *new place* for these versatile minerals to improve the quality and cut the processing costs of petroleum products.

NEW BULLETIN! "Preparation of Petroleum Feeds for Platinum Catalysts"
is just off press. Check the coupon for prompt mailing of your personal copy, and for other assistance, if desired.

ATTAPULGUS **ATTAPULGUS PRODUCTS** *from*

MINERALS & CHEMICALS CORPORATION OF AMERICA
14 ESSEX TURNPIKE MENLO PARK, NEW JERSEY

ALWAYS A BETTER WAY . .

MINERALS & CHEMICALS CORPORATION OF AMERICA
14 Essex Turnpike, Menlo Park, N. J.

☐ Please send me "Preparation of Petroleum Feeds For Platinum Catalysts"

☐ I'd like to talk to a representative about a specific feed stock problem.

name _____ title _____

company _____

address _____

city _____ zone _____ state _____

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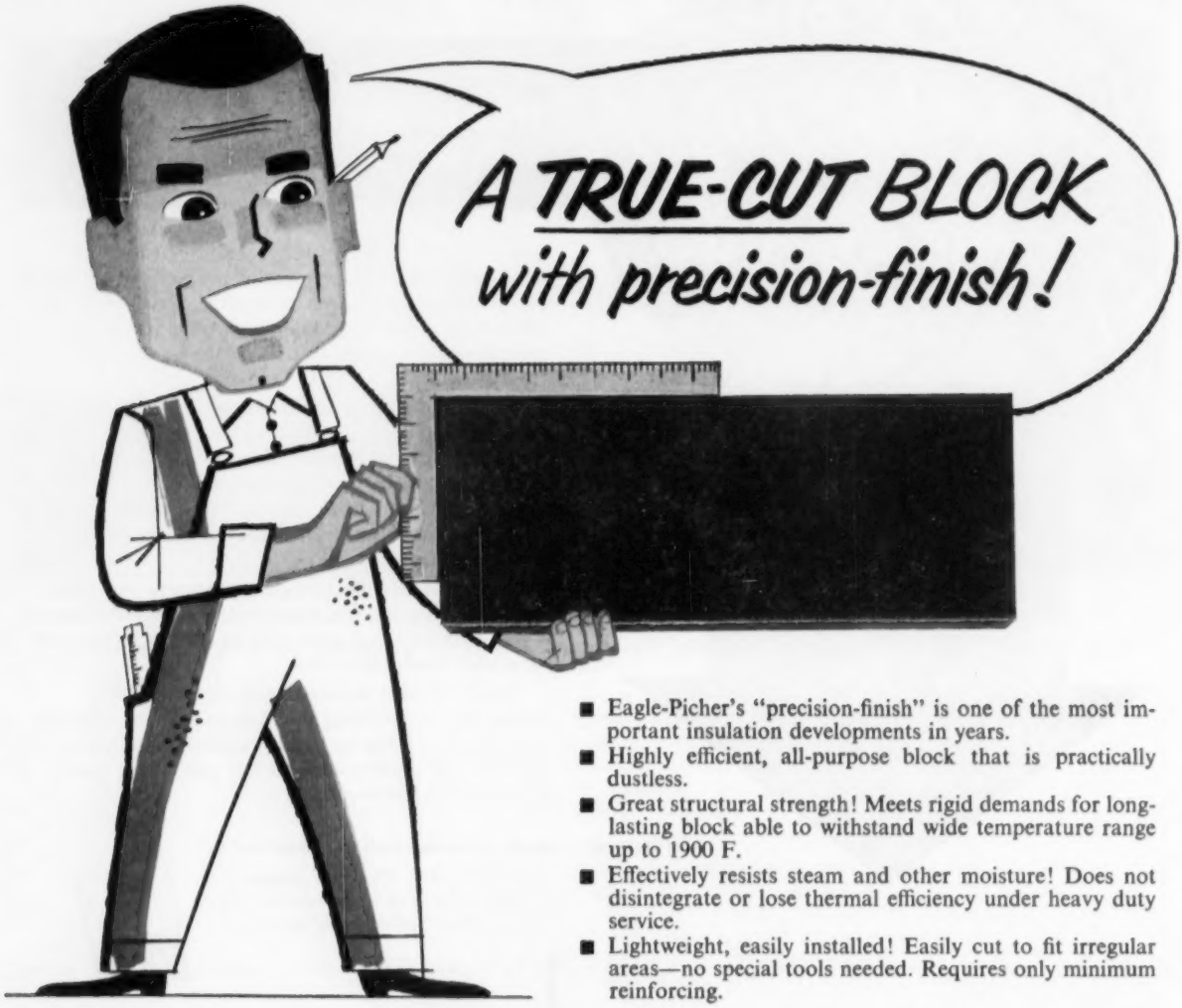
EAGLE-PICHER
PV SUPERTEMP
BLOCK INSULATION



- Eagle-Picher's "precision-finish" is one of the most important insulation developments in years.
- Highly efficient, all-purpose block that is practically dustless.
- Great structural strength! Meets rigid demands for long-lasting block able to withstand wide temperature range up to 1900 F.
- Effectively resists steam and other moisture! Does not disintegrate or lose thermal efficiency under heavy duty service.
- Lightweight, easily installed! Easily cut to fit irregular areas—no special tools needed. Requires only minimum reinforcing.

FREE SAMPLE! WRITE TODAY! You'll sell yourself on the new "precision-finish" once you compare Eagle-Picher PV Supertemp Block to other insulating blocks.

(Member of Industrial Mineral Fiber Institute)

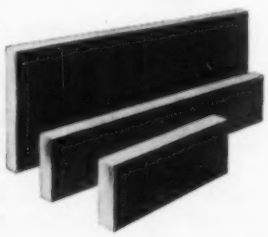
Since 1843

EAGLE EP PICHER

EAGLE-PICHER

The Eagle-Picher Company • General Offices: Cincinnati 1, Ohio

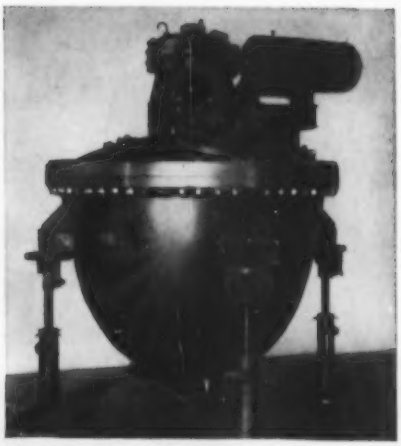
PRODUCING A COMPLETE LINE OF INDUSTRIAL INSULATIONS



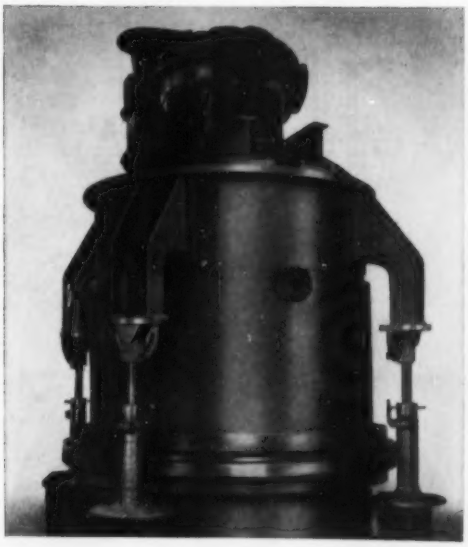
(Conforms to Commercial Standard CS 117)

For more data on advertised products, use Readers' Service Cards, last page.

Buflovak...50 years experience matching kettles with requirements



500-gallon one-piece cast jacketed Pressure Saponifier with Double Motion Agitator.



1500-gallon Dowtherm heated, jacketed Kettle with Double Motion Agitator and Thermocouple.

3000-gallon steam jacketed, fabricated steel Grease Mixing Kettle.

To a great extent, processing profits depend upon the quality and efficiency of the processing equipment. Proper equipment design is in turn determined by such factors as end product, quantities to be handled, method of heating and cooling, agitators and drive to be employed, heat source, and high or low temperature control.

Blaw-Knox engineers have the years of practical experience and technical know-how necessary to combine all these factors into equipment that will best meet *your* processing needs. We can build kettles to your design; or, engineer, design and construct kettles to meet your requirements. Either way, Buflovak Kettles are your assurance of highest processing profits. Write or call us today about *your* processing problem.

a broad process equipment service

Kettles of every description constitute but one phase of Blaw-Knox Process Equipment design, engineering and fabrication service for the chemical, food, pharmaceutical, plastic and resin, petroleum, rubber and other industries:

EVAPORATION • DRYING • FLAKING
MIXING • IMPREGNATING • REACTION
VULCANIZING • SOLVENT RECOVERY
SOLVENT EXTRACTION • STERILIZING
CRYSTALLIZATION • DISTILLATION
POLYMERIZATION • GAS CLEANING
GAS ABSORPTION • VAPORIZATION
CONDENSATION • HEAT TRANSFER
LOW AND HIGH PRESSURE PROCESSING

Write for Bulletin 356-R for more information on Buflovak Processing Kettles for heating, cooling, mixing, drying, concentrating, crystallizing and reactions.

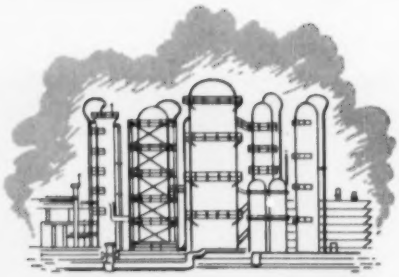
50th Anniversary BLAW-KNOX 1906 1956

BLAW-KNOX COMPANY
Buflovak Equipment Division
1601 Fillmore Avenue, Buffalo 11, New York

Makers of process equipment engineered for any pressure, temperature, capacity or reaction

For more data on advertised products, use Readers' Service Cards, last page.

TRECo TRECo TRECo TRECo TRECo TRECo



DESIGN
ENGINEERING
CONSTRUCTION

TRECo

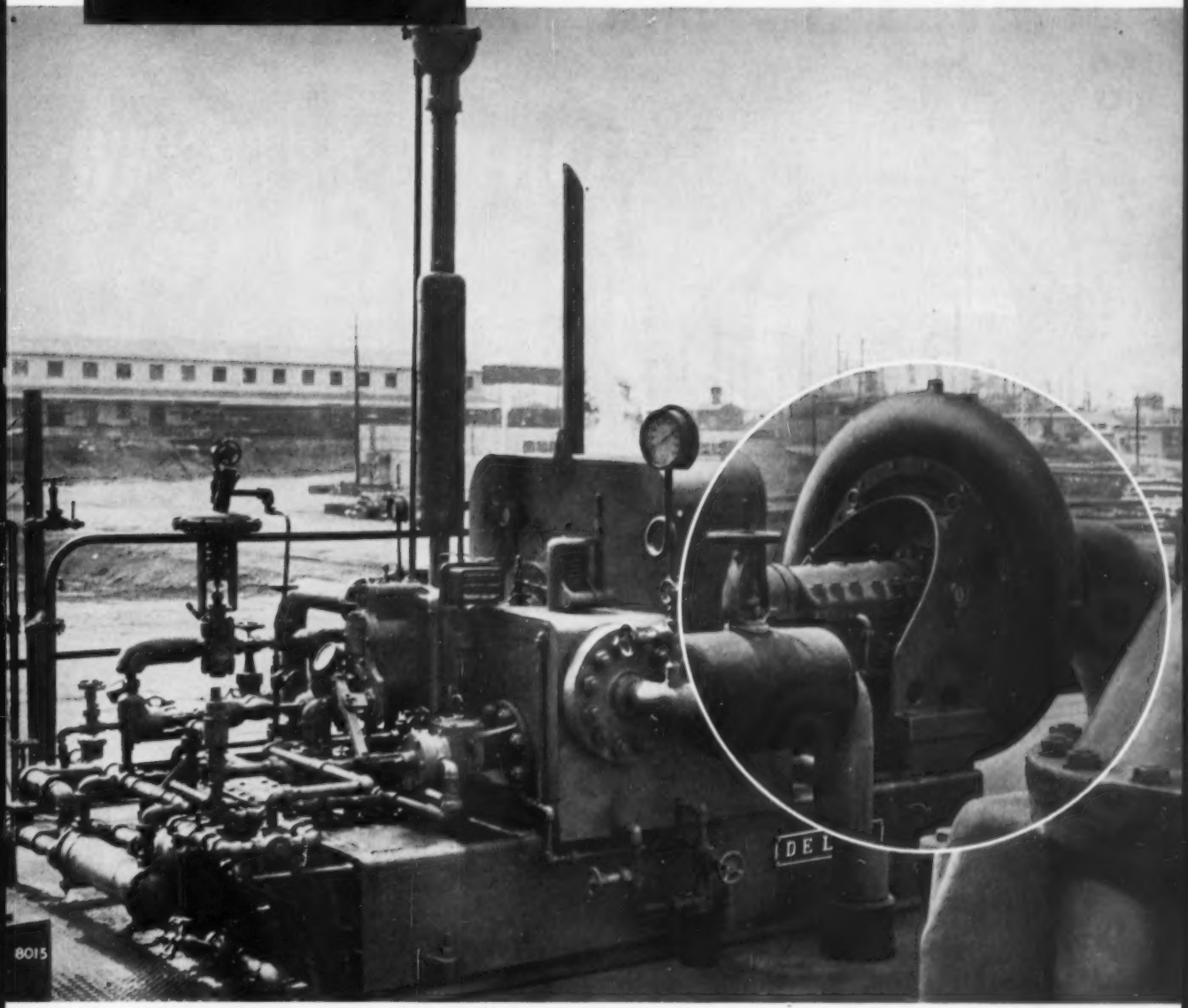
A DIVISION OF VITRO CORPORATION OF AMERICA

The REFINERY ENGINEERING Company

NEW YORK TULSA TORONTO

DE LAVAL
CENTRIFUGAL
BLOWER

controls air in cat cracker at Standard Oil of California



This De Laval centrifugal blower, selected by the Fluor Corporation, is on stream at the Standard Oil Company of California's new cat cracker in El Segundo. For control air service, this blower delivers 9,500 cfm; inlet pressure is 15.4 psig and discharge pressure 19.4 psig. The blower is driven by a De Laval 220 brake horsepower MCP Turbine operating at 800 psig with a temperature of 650 F; it has all labyrinth shaft packing for high back pressure service.

In addition to single stage designs, De Laval makes a complete line of equipment for all refinery services, including multi-stage compressors driven by De Laval multi-stage turbines for condensing, non-condensing and automatic extraction applications.

Send for new Bulletin 0504

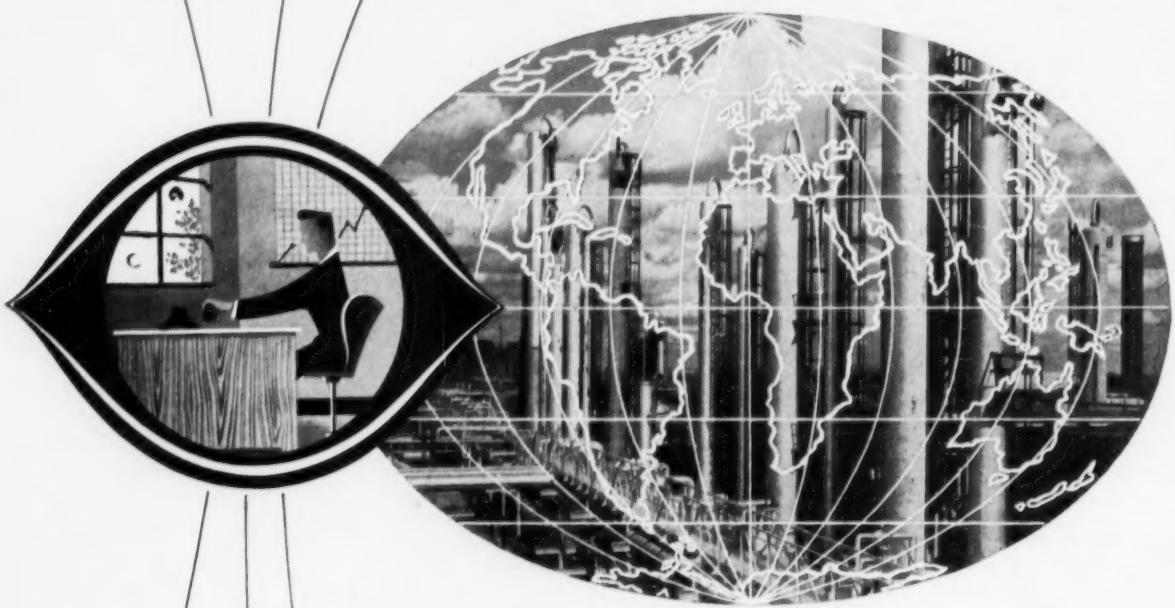
DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY
811 Nottingham Way, Trenton 2, New Jersey

OL 329

Newalls

OFFERS TECHNICAL SERVICE ON SITE



* **OIL REFINERIES** for which Newalls have supplied insulation materials include the following:

BELGIUM
- * Petrofina, Antwerp
- * Esso Antwerp
- * Albatros Antwerp

BRAZIL
- * Cubatao

FRANCE
- Port Jerome
- Du Nord (Dunkirk)
- Gonfreville
- Petite Couronne
- Berre

INDIA
- * Stanvac, Bombay

MIDDLE EAST
- * Aden
- Ras Tanura
- Bahrain

VENEZUELA
- Cardon
- * Amuay

* Insulated wholly with Newalls Insulation Company Limited's materials.

NEWALLS ARE CONSTANTLY solving insulation problems all over the world. From Antwerp to Adelaide, Newalls insulation materials are meeting every requirement in Heat, Cold and Sound Insulation. But Newalls service offers more than the supply of materials.

Newalls can also provide supervisory service to smooth out application difficulties on site. Newalls technical staff can handle the specifications and estimating work for any kind of plant, large or small. Calling in Newalls Technical Advisory service is the quickest way to insulation efficiency.

Newalls ***TECHNICAL ADVISORY SERVICE***

NEWALLS INSULATION CO. LTD.,
Head Office: WASHINGTON, CO. DURHAM ENGLAND
A member of the TURNER & NEWALL ORGANISATION
Agents and Vendors in most markets abroad.

WHY PAINT PIPELINES

when Plicoflex does 2 jobs in 1!

Built-In Color Coding Plus Lasting Corrosion Protection

Plicoflex No. 340 is a laminated tape whose primary job is protecting pipelines against corrosion. Available in black, white and six brilliant colors, it can do an *extra* job for you—eliminate frequent costly painting of lines for color-coding purposes—at very low cost. And the color is in the tape ... uniform in thickness ... far outlasts any paint job!

That's one bonus. Now look at some of the others:

Highest Shock-Impact Resistance... Made of tough polyvinyl chloride film laminated to butyl rubber, Plicoflex No. 340 Tape offers rugged extra heavy thickness together with ample resiliency to resist damage from accidental blows.

No Moisture Migration... The engineered cold-flow properties of Plicoflex compounded butyl rubber fill irregularities on pipe, provide a perfect seal at the overlap.

Stronger, Permanent Bond... Solid non-volatile film that will not support combustion and provides a permanent colored coating which will not chip or flake. Quickly forms an *inseparable* bond to the pipe.

Low Cost... Plicoflex job-site application methods cut coating manpower requirements to a minimum; and in most cases cost less to apply than other coatings.

Want more? Write, wire or phone

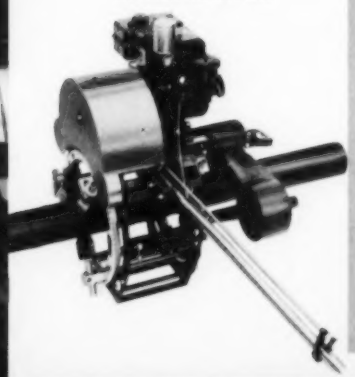
PLICOFLEX
TRADE MARK

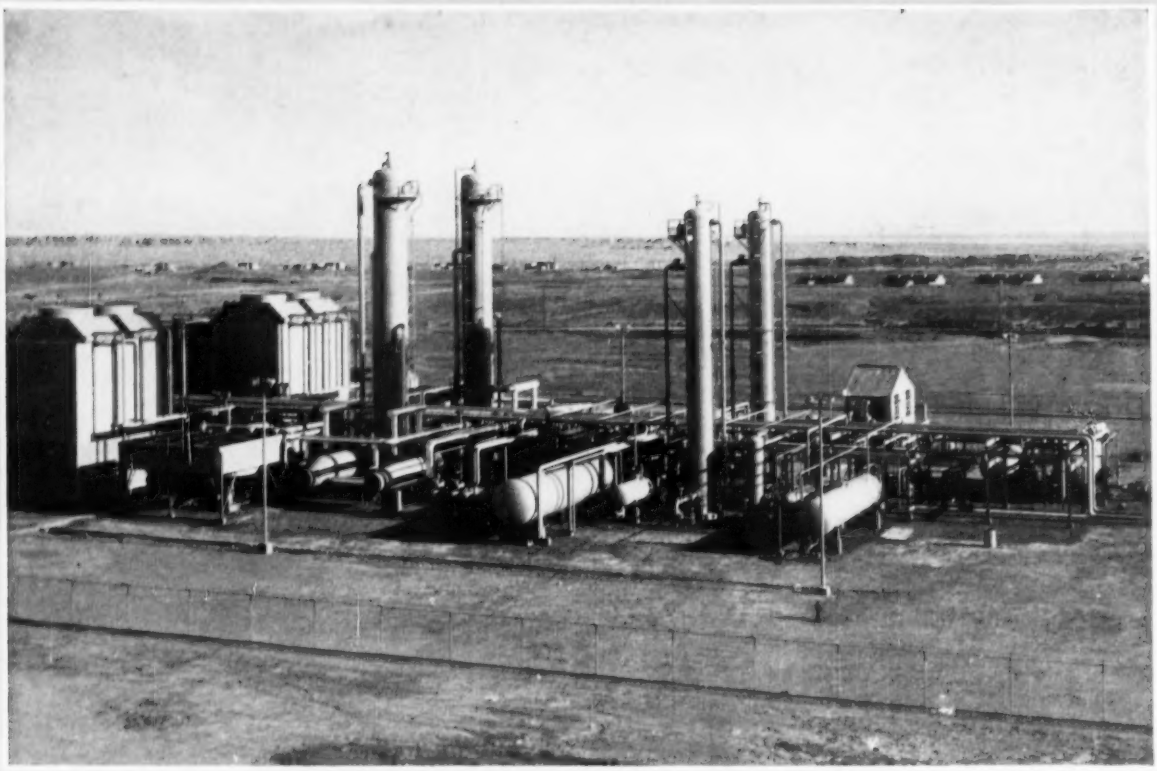
PLICOFLEX, INC.

1566 EAST SLAUSON AVENUE • LOS ANGELES 11, CALIF. • LOGAN 8-4335

Teletype No. LA 189

You can hand-wrap Plicoflex ... or turn the job over to this new lightweight wrapping machine, the Plicoflex **SPEEDMASTER**



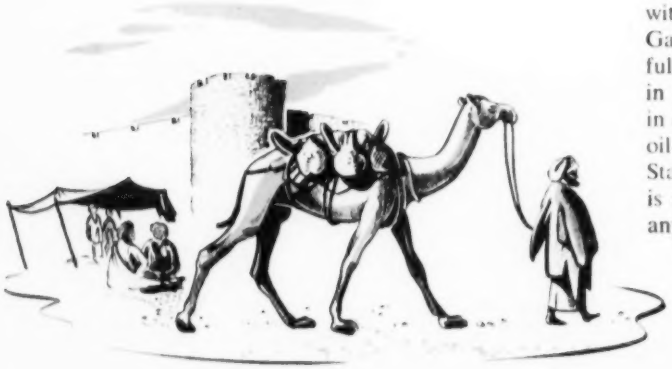


Sui GAS STARTS TO KARACHI

This plant, the first of its kind in Asia, is located in the Sui Gas Field 350 miles northeast of Karachi in West Pakistan. It processes sour gas, removing sulphur compounds and water vapor, preparing the gas for transportation and consumption. It is a vital part of a project from which will accrue great economic advantage to Pakistan.

The work of Hudson included design, procurement of equipment, transportation, and erection using English, American and native labor.

Despite the remoteness of the plant site, the rail terminus being 40 miles across the desert, and air temperatures as high as 125 F. in the shade, the plant was completed in 12 months from start of design work.



Hudson is proud to have collaborated with Pakistan Petroleum, Limited, and Sui Gas Transmission Corporation in the successful completion of this first project of its kind in Asia. The experience of Hudson gained in over 30 years in design and construction of oil and gas processing plants in the United States, Europe, Mexico and South America is available for any project large or small in any part of the world.

HUDSON

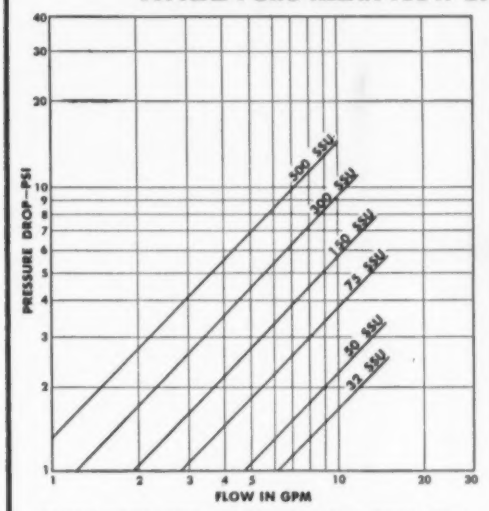
ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

DESIGN AND APPLICATION NOTES ON

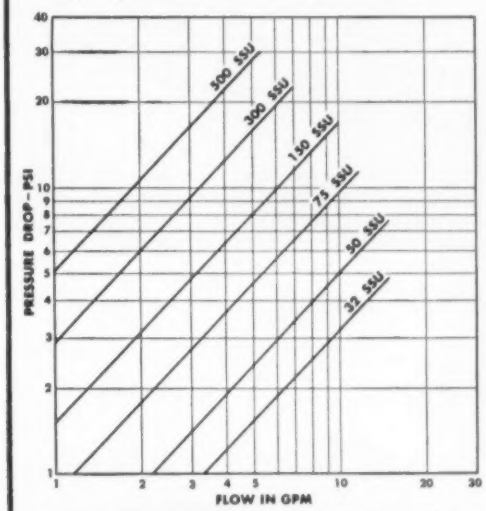
Cuno's new Poro-Klean Filter

TYPICAL PORO-KLEAN FLOW DATA



CYLINDRICAL TYPE

FLOW DATA FOR TYPICAL CYLINDRICAL-TYPE, coarse-grade, PORO-KLEAN filter element, fluid viscosity as parameter. Filtration to 15 microns.



CELL TYPE

FLOW DATA FOR TYPICAL CELL-TYPE, medium-grade, PORO-KLEAN filter element, fluid viscosity as parameter. Filtration to 5 microns.

Precision 3-to-30 micron filter for high temperature and high pressure

PORO-KLEAN, Cuno's new porous stainless steel filter material, now offers the chemical, petrochemical, nuclear, and process industries true micronic filtration for temperatures to 900°F and differential pressures to 2000 psi.

Standard in 316 stainless steel, with low carbon content (0.03 to 0.05% max.), PORO-KLEAN is an ideal filter material for use in applications requiring corrosion resistance, high strength (ultimate tensile strength: 25,000 psi), high resistance to hydraulic shock, or positive freedom from fluid contamination.

Typical PORO-KLEAN applications, already in use in the chemical and process industries, are listed below. Approximate flow-rate curves for typical cell and cylindrical standard elements are shown at left (for exact data, see your Cuno representative).

TYPICAL PORO-KLEAN APPLICATIONS

TO REMOVE:

- Resin and airborne contamination from demineralized water
- Fixed-bed catalyst fines from petroleum products
- Over-cooked gels from polymers
- Radioactive contamination from light and heavy water
- Fine precoat particles downstream from primary filters
- Contamination and/or catalysts from high-temperature and high-pressure refinery gases
- Metal oxides from molten sodium, sodium-potassium, and bismuth
- Iron oxides from fuels
- Rust from steam
- Foreign matter from pharmaceuticals

TO RECOVER:

- Catalysts from gases and liquids

TO DISPERSE:

- Gases into liquids and other gases

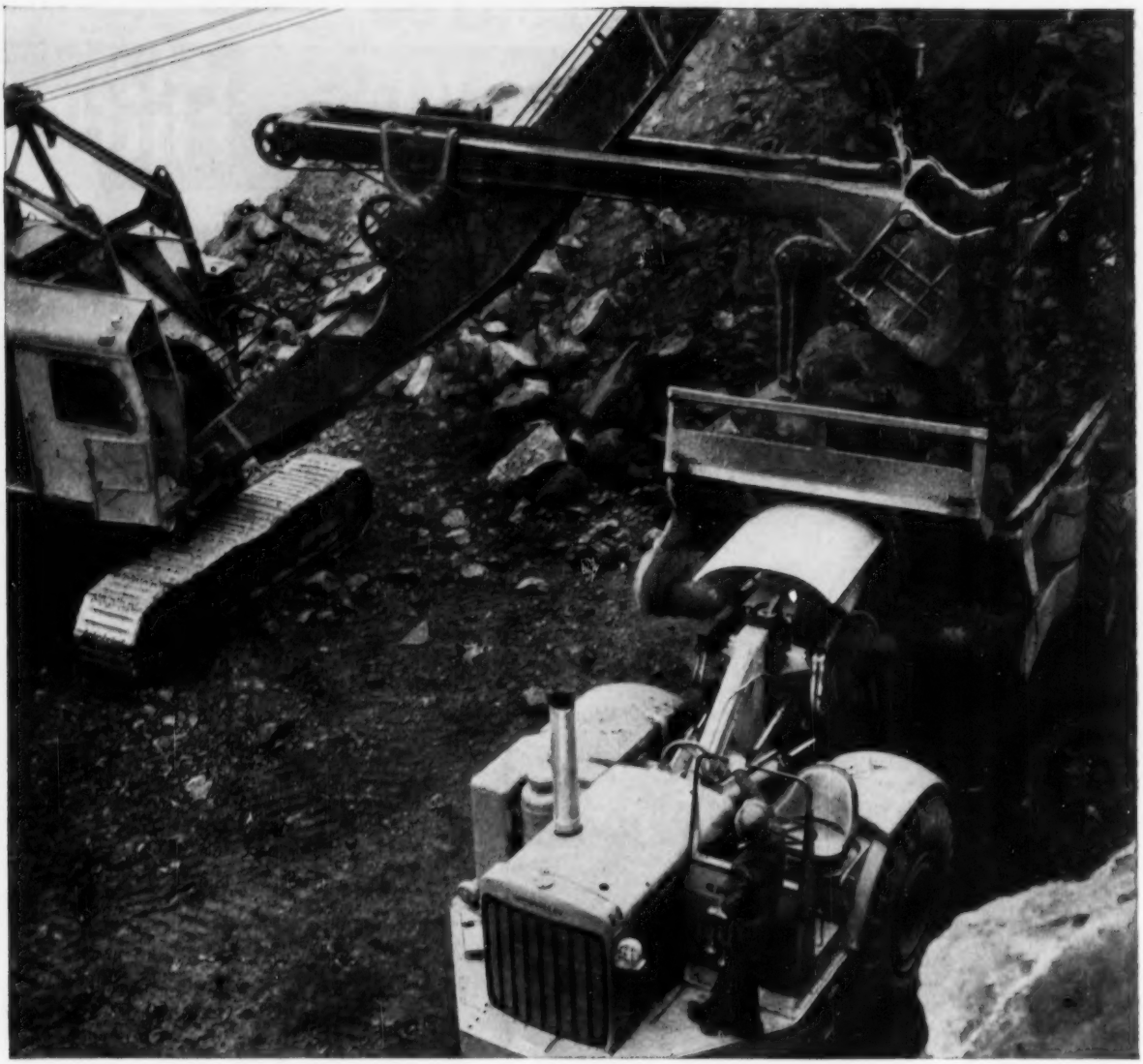
If you have problems like these, let Cuno engineers help you apply PORO-KLEAN to their solution. See your Cuno representative, or write Cuno Engineering Corporation, 33-5 South Vine Street, Meriden, Conn. 5.20

CUNO

ENGINEERED FILTRATION

Removes More Sizes of Solids From More Kinds of Fluids

AUTO-KLEAN (edge type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound) • PORO-KLEAN (porous stainless steel)



to meet exacting lubrication standards, specify

ENJAY PARANOX®

detergent-inhibitor additives

Refiners and blenders from coast to coast count on Enjay for a *complete* line of highest-quality petroleum additives. An important part of this line is the Enjay Paranox group, the detergent-inhibitor additives famous around the world for use with every type base stock.

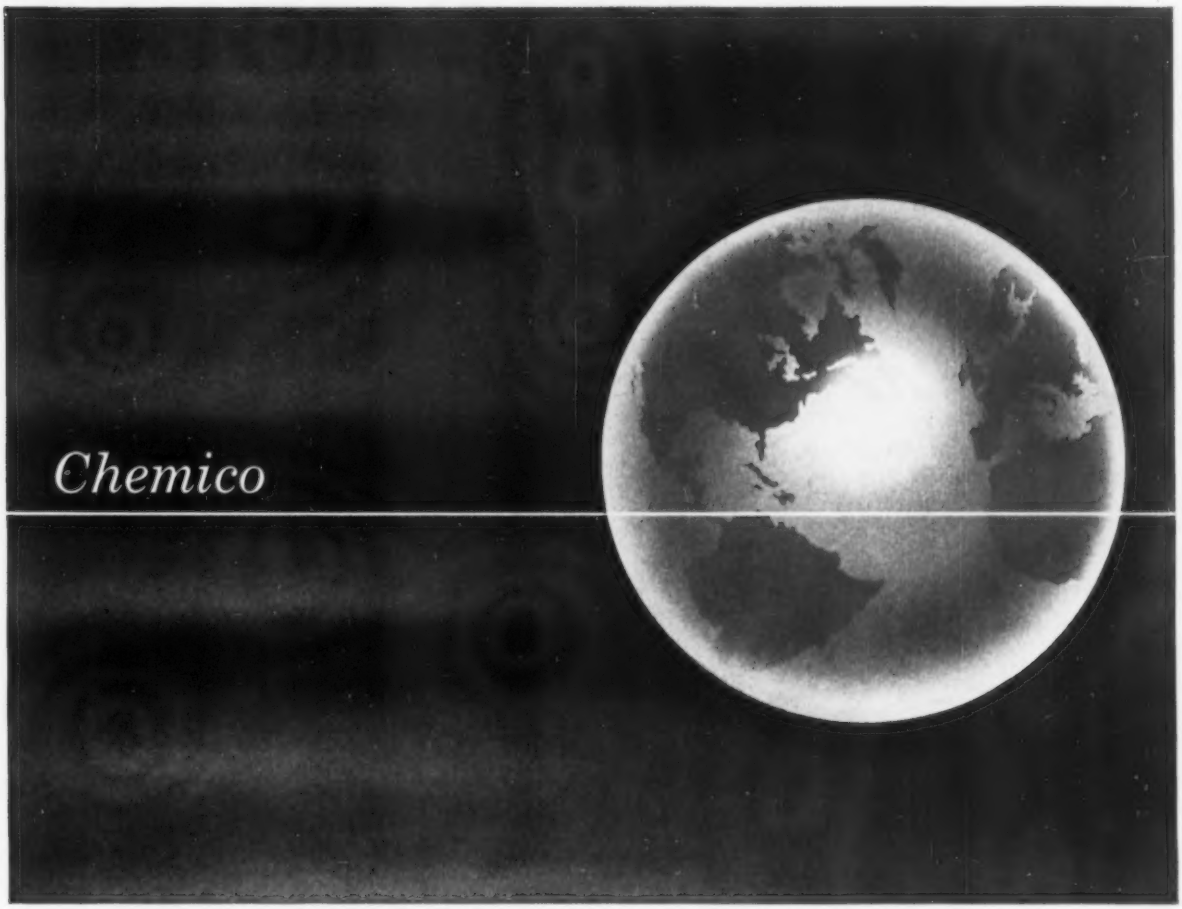
You are assured a prompt solution to your additive problems at Enjay. You get the benefit of the Enjay Company's extensive experience in working with oil companies and leading engine manufacturers to develop lubricating oil additive formulations for a wide variety of military and commercial uses.

For complete information write, wire or phone the Enjay Company—your only source for a *complete* line of additives (Paramins ®) for fuels and lubricants.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st STREET, NEW YORK 19, N. Y. • Other offices: Akron, Boston, Chicago, Tulsa



25%

of the world's synthetic ammonia *produced in plants designed by* CHEMICO

Chemico engineered the first synthetic ammonia plants ever to be built in the United States, Mexico, Poland, Egypt, Israel, India, China, the Philippines—even the USSR. In all, forty-nine Chemico-designed ammonia plants are in operation all over the world and the *fiftieth*, for installation in Japan, is presently being designed for Nihon Gas K. K.

With over 41 years of world-wide experience, Chemico continues unceasingly to pioneer improvements on existing chemical processes—Ammonia, Methanol, Nitric Acid, Ammonium Nitrate, Urea, etc.—and to incorporate the latest technical advances in engineering design.

Chemico initiative is exemplified in the new Pensacola Plant of Escambia Bay Chemical Corporation, the first ammonia plant anywhere to use hot potassium carbonate solution for the removal of carbon dioxide from ammonia synthesis gas.

CHEMICAL CONSTRUCTION CORPORATION
A UNIT OF AMERICAN CYANAMID COMPANY
Designers and constructors of complete plants and facilities for the chemical and petrochemical processing industries for over 40 years
525 WEST 43rd STREET, NEW YORK 36, N. Y.
Technical Representatives: Cyanamid Products Ltd., London, South African Cyanamid (Pty.) Ltd., Johannesburg. Cable Address: CHEMICONST, N. Y.

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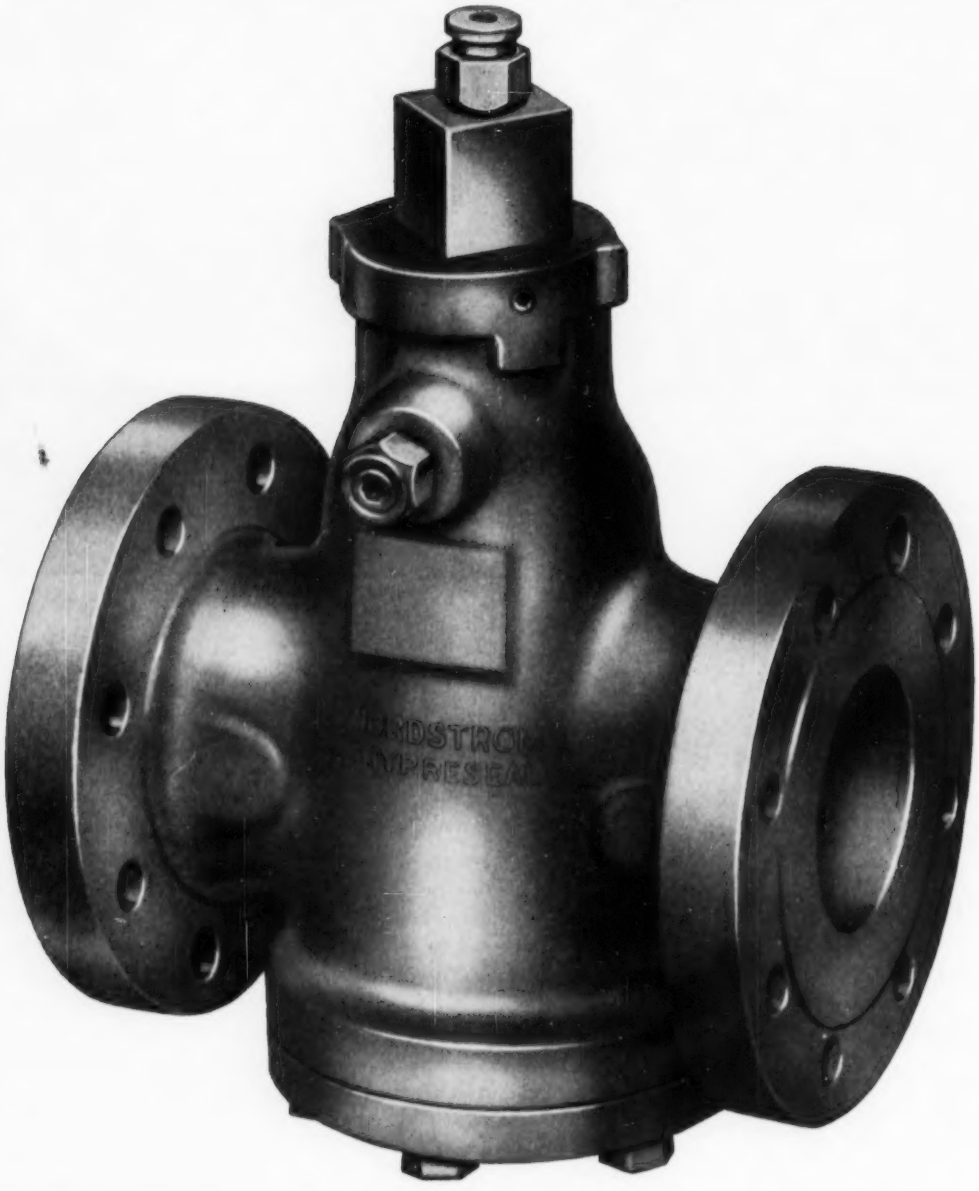
ROCKWELL-

Often Copied...



40th YEAR *of*

Nordstrom VALVES

Never Equaled

Rockwell-Nordstrom is the *original* lubricated plug valve. But that is only part of the story behind forty years of lubricated plug valve leadership. Starting with the first valve, *every major development* in lubricated plug valves has come to you *first* in a Rockwell-Nordstrom valve. Today, as always, the *oldest* lubricated plug valve is also the *newest* in terms of better performance, longer life and lower cost.

Below are listed only a few of the more than ninety basic Rockwell-Nordstrom valve and lubricant innovations. They are the reasons why Rockwell-Nordstrom valves—although often copied—have *never* been equaled. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee: Peacock Brothers Limited

ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-off

first... for forty years *Here are just a few of more than ninety basic valve and lubricant innovations that have maintained the leadership of Rockwell-Nordstrom valves—through better performance, longer life and lower cost.*

- **FIRST Lubricated Plug Valve**
- **FIRST Sealdport* pressurized lubricant sealing**
- **FIRST Hydraulic plug jacking for fast, dependable operation**
- **FIRST Hypreseal* for high pressure plug valve service (still exclusive)**
- **FIRST Special plug and body coatings—longer life on "tough" services**
- **FIRST Automatic shut-off valves for gas pipelines**
- **FIRST "Self-Energizing" valve lubricants**
- **FIRST Line of special and general purpose valve lubricants**
- **FIRST Multiport lubricated plug valves for 3-way and 4-way flow control**
- **FIRST Lubricated plug valve for low temperature service**
- **FIRST Venturi valve for lower cost on larger lines**
- **FIRST Lubricated plug Christmas tree valves**

*Registered trade mark Rockwell Manufacturing Company

lubricated plug valve leadership

For more data on advertised products, use Readers' Service Cards, last page.

Rough treatment proves

New Rheem-baked linings can take it

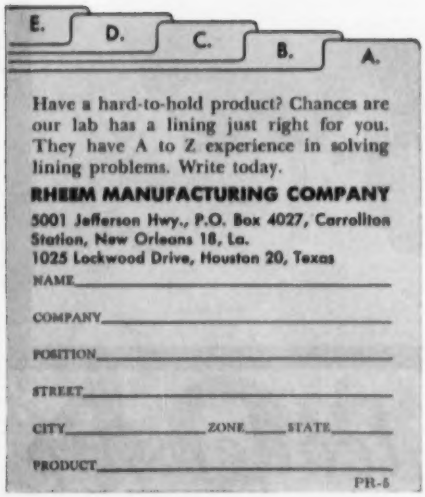
Traveling's hard on shipping drums – even when they don't show it.

Riding under a blistering sun one day, drums may be standing in snow the next. They get bounced and banged around – not always *hard*, but certainly *often*. All this shock adds up.

Rheem engineers stay a jump ahead of the problem. They speed up road abuse in "torture" labs by testing drums filled with actual products at various temperatures.

We've found that linings applied in extra-careful ways stand up better and longer under punishment. That's why we use 2-oven baking to cure our linings. Drums have a *"stand-up"* oven for more even baking. Their tops and bottoms have a separate oven. It's fussy detail, we know, but curing is a critical step in applying our linings. And we take lots of other fussy steps before the curing—like shot-blasting our steel drums to physically clean and roughen them – to give the linings a lasting, "fingered" grip.

These steps have all come out of a search for new and better linings – new and better protection – for all kinds of products. A *continuing* search by the world's leading producer of steel shipping containers.



Have a hard-to-hold product? Chances are our lab has a lining just right for you. They have A to Z experience in solving lining problems. Write today.

RHEEM MANUFACTURING COMPANY

5001 Jefferson Hwy., P.O. Box 4027, Carrollton Station, New Orleans 18, La.
1025 Lockwood Drive, Houston 20, Texas

NAME_____

COMPANY_____

POSITION_____

STREET_____

CITY_____ ZONE_____ STATE_____

PRODUCT_____

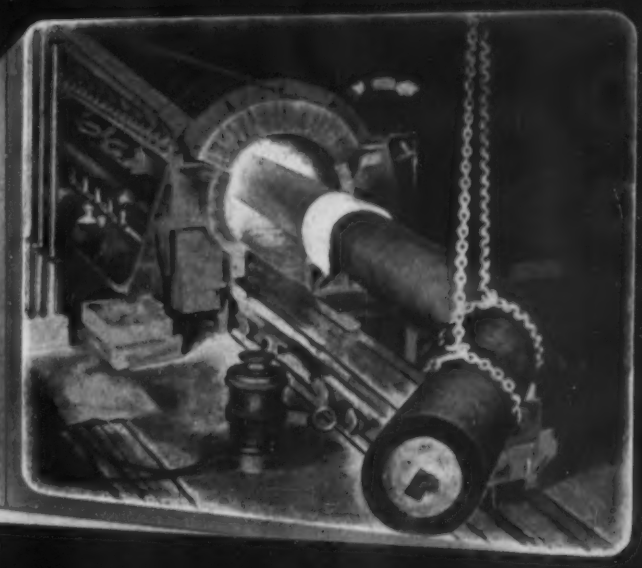
PR-5

YOU CAN RELY ON Rheem MANUFACTURING COMPANY

RICHMOND AND SOUTH GATE, CALIF.; HOUSTON, CHICAGO, NEW YORK, NEW ORLEANS; LINDEN, N. J. AND SPARROWS POINT, MD.

Available to Company Groups and Technical Associations

INFORMATIVE!
INTERESTING!



"PREFABRICATED PIPING by GRINNELL"

A 16mm. sound motion picture, in full color. Provides an educational close-up of latest techniques in the shop fabrication of piping. Available for showing without cost.

Bending

Stress Relieving

Automatic Welding

Ultrasonic Testing

"Prefabricated Piping by Grinnell" is a fascinating and factual film. Produced by the 100-year old Grinnell Company, it sheds new light on the complex subject of prefabrication of piping . . . answers with complete authority many of the questions dealing with shop vs. field fabrication.

Now you can see for yourself how the experts bend 20-inch pipe, with walls four inches thick; how pipe is sand-packed to prevent collapse in bending; how alloy pipe is pre-heated to preserve its special characteristics; how to stress-relieve after bending or welding; how to cold bend pipe; extrude branch outlets; perform automatic welding. You can look over the shoulders of the experts . . . during radiographic inspection, hydrostatic testing, and photomicrographic examination.

There is no charge for this film. Engineering societies and engineering departments that desire to show this picture should address their local Grinnell Supply Sales Office, or Publicity Department, Grinnell Company, Inc., 282 West Exchange St., Providence, R. I. Requests will receive prompt attention.

For more data on advertised products, use Readers' Service Cards, last page.

Here's The Most Versatile Pilot Ever Offered!

BS&B Universal Control Pilot With Type 73-26 Instrument Air Regulator.

It's The New BS&B Universal Control Pilot

For . . . ● Temperature Control ● Pressure Control ● Liquid Level Control

FEATURES

- ✓ **Linear Response.**
- ✓ **Factory Calibration.**
- ✓ **Excellent Frequency Response.**
- ✓ **Micrometer Adjustment.**
- ✓ **Outstanding Performance Repeatability.**

This trim modern-looking weatherproof aluminum case houses the new BS&B Universal Pilot—one of the simplest, yet most versatile control pilots you've ever seen!

Only 8″ x 8″ x 4″ in size, this pilot offers a wide throttling range and high-low snap-acting settings without additional parts. Feed orifice has a push-button cleanout. All parts in the lower half of the case including the stainless steel power unit, micrometer adjusting nozzle, compensating bellows, proportioning band and gauges are common to all three types of service, and are interchangeable to reduce maintenance cost and inventory. Where regulator is required, the new BS&B 73-26 is provided to furnish a finely filtered supply of air or gas.

The pilot unit is equally adaptable to wall mounting, remote mounting, yoke or diaphragm mounting, or flush instrument board mounting. An unusual feature, designed for your convenience, is the double-hinged door which opens from either side!

For Full Details On The BS&B Universal Pilot, Contact Your BS&B Representative Or Write To . . .

EFFICIENCY OVER 60 YEARS BS&B RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.
Controls Division, Dept. 4-F5
7500 East 12th Street • Kansas City 26, Missouri

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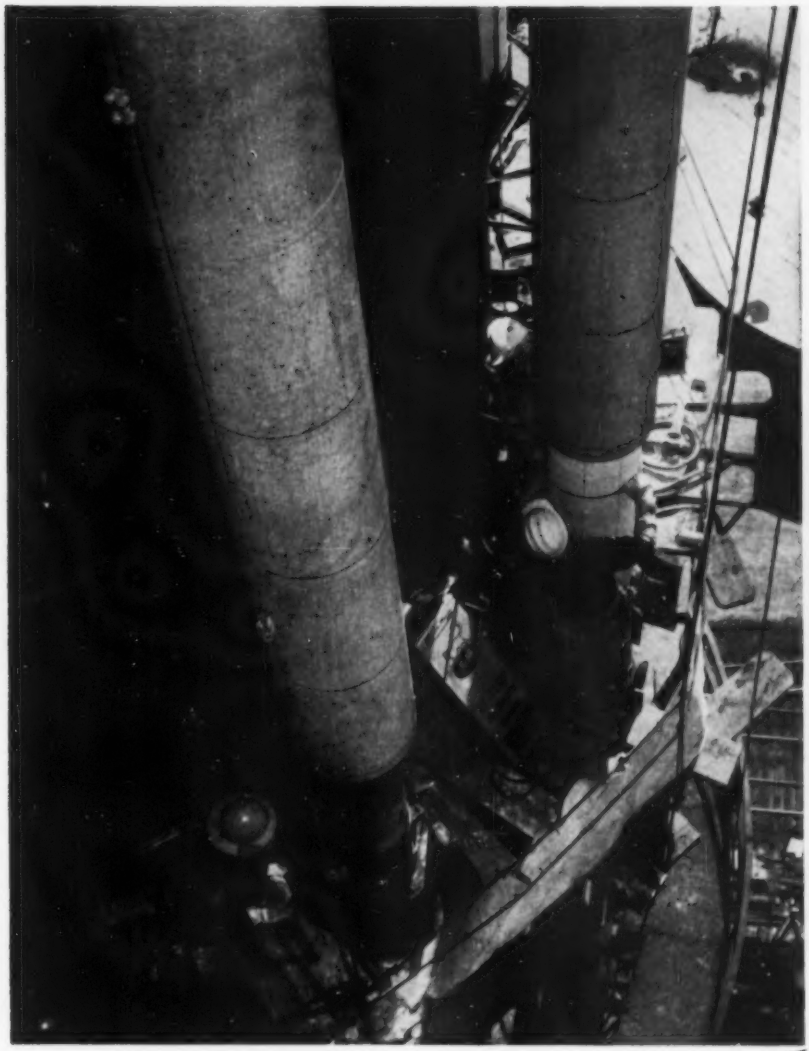
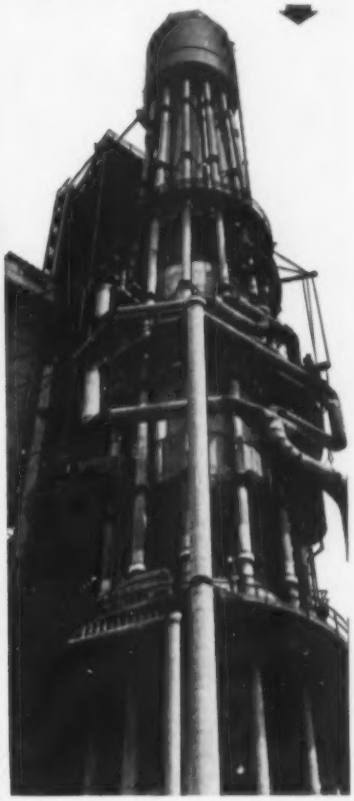


The World's Largest Houdriflow, at the Sun Oil Company refinery, Marcus Hook, Pa., is 350 feet high. Lift piping to its reactor tank is insulated with a combination of K&M Hy-Temp andK&M "Featherweight" 85% Magnesia.



Easily Applied, Hy-Temp and "Featherweight" insulations quickly go on 14" lift pipes high above ground. This huge catalytic petroleum cracking unit embodies some 2½ miles of insulated piping. Insulation contractor: Armstrong Cork Company.

K&M Thermal Insulations help keep the world's biggest "cat" purring

It takes plenty of heat to crack petroleum. This king-size catalytic cracking plant ("cat") works 24 hours a day, seven days a week—with operating temperatures as high as 1500°F. K&M Thermal Insulations minimize heat loss and keep heat on the job here, just as they do in power plants, factories, and institutions the country over.

K&M "Featherweight"® 85% Magnesia and Hy-Temp Insulations withstand moisture, vibration, frequent temperature changes. For efficiency to 1900°F., these insulations are applied in combination, with staggered joints. This eliminates heat loss that normally occurs in single-layer installations when expansion causes joints to open. "Featherweight" is efficient to 600°F. when used solely.

Plan your new plant with these heat-saving, cost-saving insulations in mind. Bring your present plant up to date with K&M Thermal Insulations. Contact your K&M distributor, an experienced applicator, for full details. Or write directly to us.

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

K&M best in asbestos®

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We "Split Hairs" (and then some) to guard the quality of your Sheffield Bolts

SHEFFIELD
ARMCO

Bolt Products

Sheffield's "serv-a-bolt" package with handy dispenser end keeps your bolts in order with filing-cabinet efficiency. Makes for easier handling all around — in the workshop, in the supply room, on the truck, on the job!

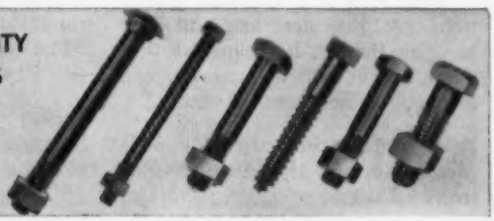
The diameter of a human hair is 27/10,000ths of an inch. The super micrometer used to check tools and gauges used in Sheffield bolt manufacture measures accuracy to 1/10,000th of an inch.

That's just one phase of Sheffield quality control. Just one reason why Sheffield bolts give you delicate precision with brute strength. Through every step of Sheffield steelmaking and bolt manufacture, we guard quality constantly with critical electronic, mechanical and chemical controls and tests. Result: bolts that install easier; hold stronger, longer.

Whether you're using bolts on "do-it-yourself" projects, or drilling rig or building construction, you'll get the finest in fastening with Sheffield bolts. Be sure with Sheffield.

SHEFFIELD STEEL
DIVISION
ARMCO STEEL CORPORATION
SHEFFIELD PLANTS: HOUSTON • KANSAS CITY • TULSA

MAKERS OF QUALITY
BOLT PRODUCTS
SINCE 1888



These are our contributions to tomorrow's better oil additives

The day is not far off when *Very Heavy Duty* lube oils will be needed to provide optimum efficiency in engine oiling systems. Better barium compounds will provide their extra measures of protection to detergent-additives.

To be prepared for this day, we have . . .

1. Substantially increased our reserves of barytes.
2. Doubled our electric-furnace capacity.
3. Developed flake Barium Octahydrate and Barium Pentahydrate . . . advanced forms of soluble barium values.
4. Initiated bulk shipment of barium alkalis in covered hopper cars to serve large additive users.
5. Pioneered production of dense, crystalline electric-furnace barium oxide.
6. Piloted an advanced barium-oxide process developed by Westvaco engineers.

When better barium-based additives are needed, still better barium compounds will be available from Westvaco.

If you are working with lube oil additives, we would like to send you a copy of the new 24-page booklet giving complete information on WESTVACO Barium Chemicals.

AMERICA'S OLDEST AND LARGEST PRODUCER OF

BARIUM ALKALIS

fmc FOOD MACHINERY AND CHEMICAL CORPORATION Westvaco CHEMICALS

Westvaco Mineral Products Division

FOOD MACHINERY AND CHEMICAL CORPORATION

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CHICAGO, ILLINOIS • CINCINNATI, OHIO • HOUSTON, TEXAS • NEWARK, CALIFORNIA

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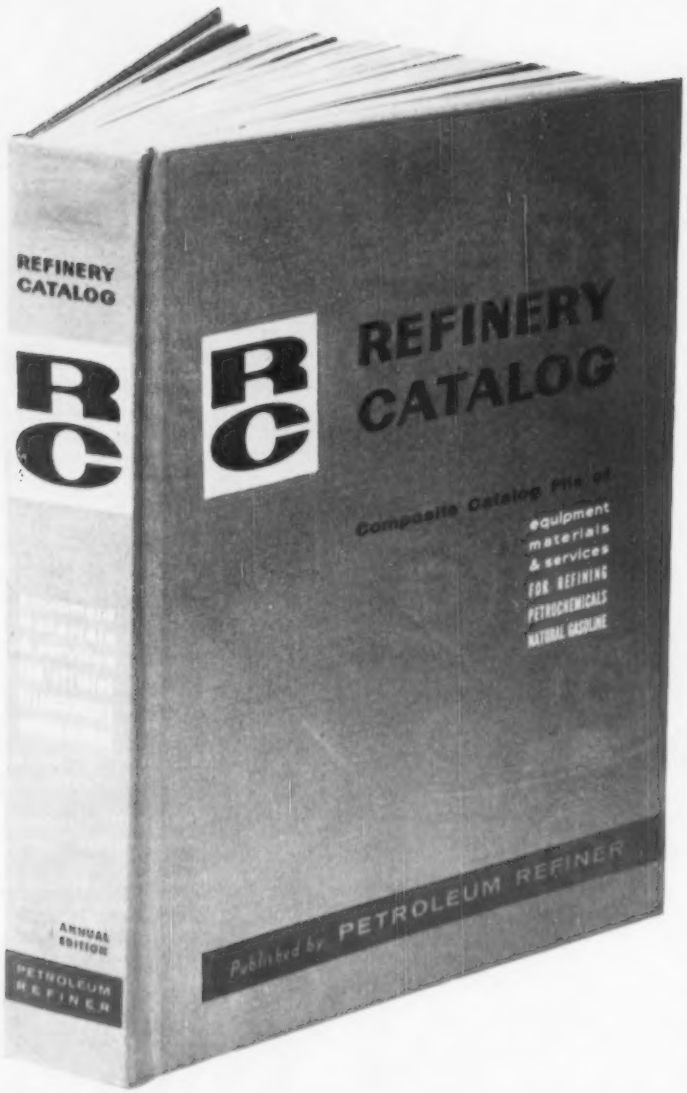
IN "NEW DRESS"

Here's how the REFINERY CATALOG's 1956 Edition appears, with new cover design featuring a large "RC" for easy identification.



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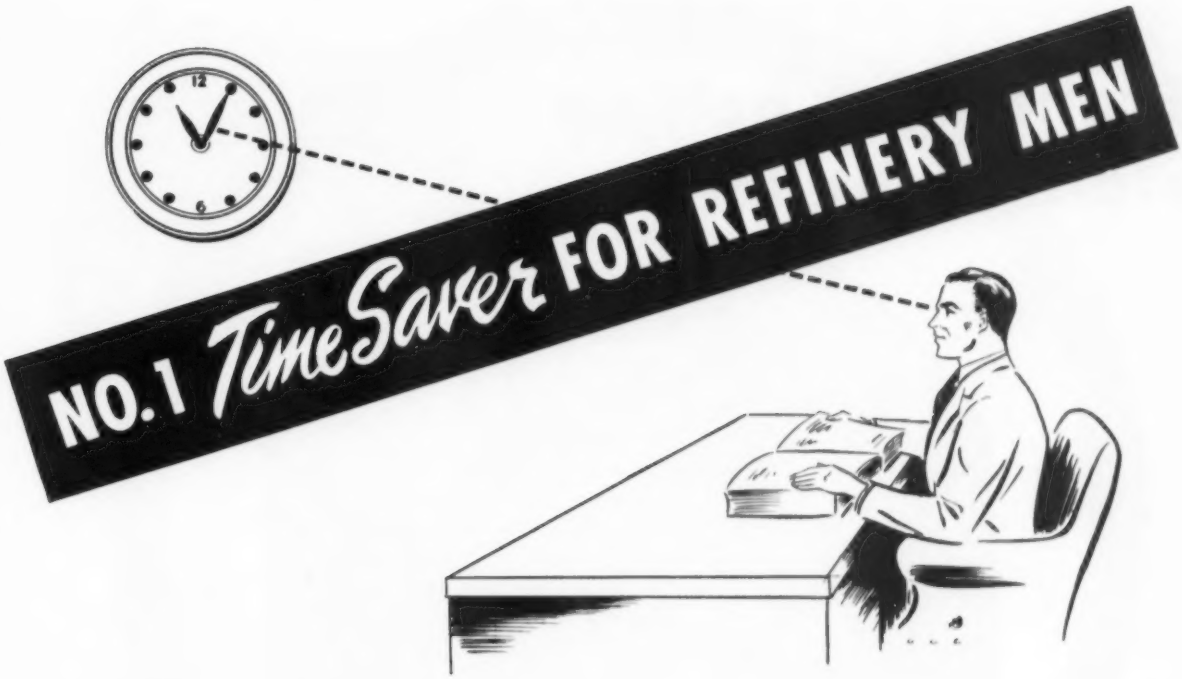

When you have to make fast, accurate buying or specifying decisions, use the REFINERY CATALOG. It is the Refining Industry's universal equipment guide . . . containing the information you need for adequate comparison on hundreds of different types of products and services.

In the new (23rd) Edition, you'll find catalog data from more than 270 companies serving this industry, authoritative specifications and data, local sources of supply . . . and a convenient index of manufacturers, equipment and services.

Remember—*it's the industry's most complete single source of equipment and service data.* Use it to help you on your job.

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Published annually by PETROLEUM REFINER, Gulf Publishing Company

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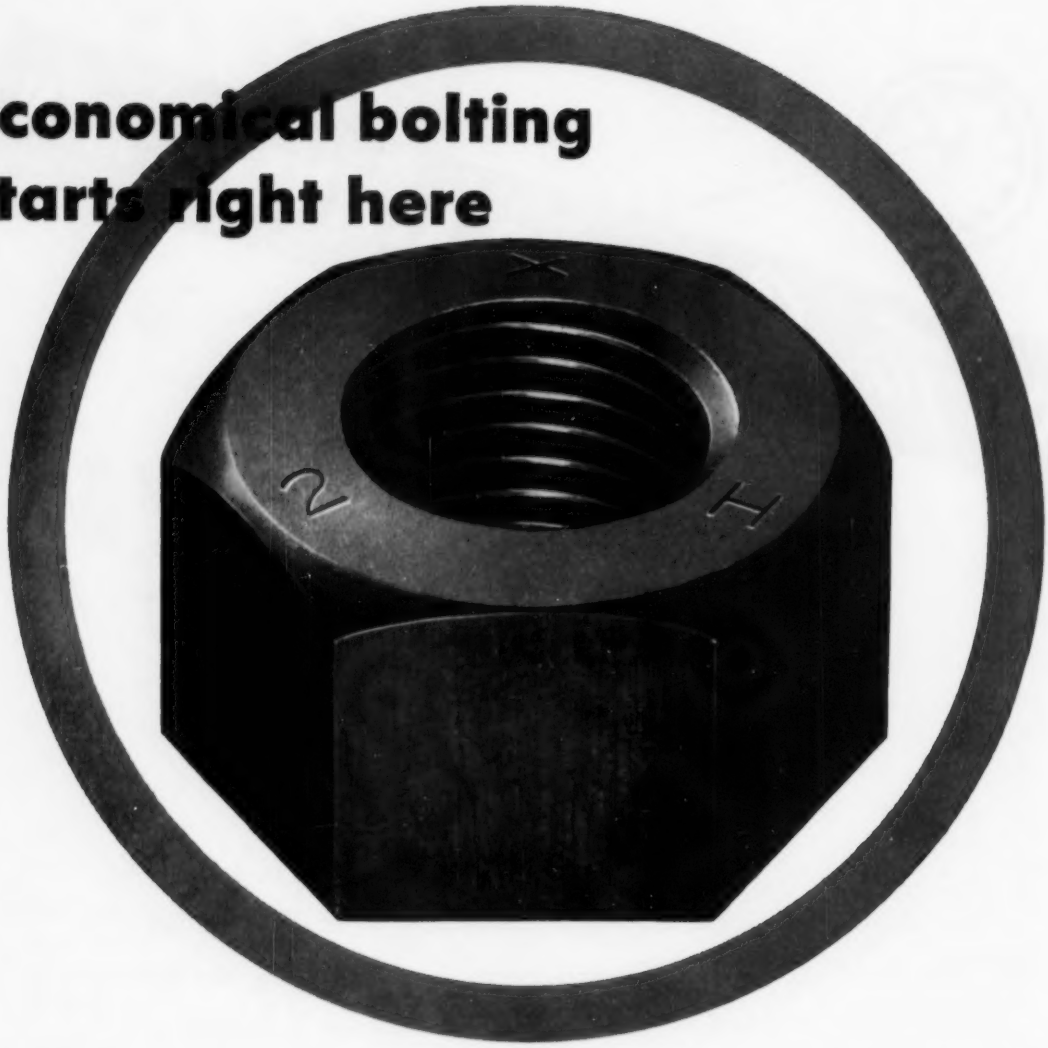
Economical bolting starts right here



In many bolting applications involving high temperatures and high pressures, the choice of nut can make all the difference between economical service and premature failure.

To assist refinery operators in utilizing different types of bolting, Bethlehem produces and stocks hexagonal nuts in four grades, each of which meets the requirements of ASTM specification A-194. Bethlehem nuts are top-quality nuts in every way. They are tapped to Class 2B fit, and are made in all sizes from ⅜ in. to 2 in.

Perhaps you may have a question or two about the type of Bethlehem nut which would be best to use with a Bethlehem carbon or alloy stud. If so, all you need do is write or phone the nearest Bethlehem sales office.

BETHLEHEM NUTS COME IN FOUR GRADES

Grade 1. Made of low-carbon steel, this nut is suitable for non-critical applications, as well as installations involving moderate temperatures. Carbon 0.15 min, phosphorous 0.05 max, sulphur 0.05 max. Brinell hardness is 120 min.

Grade 2. A medium-carbon steel nut, intended for use at moderate temperatures and pressures. Carbon 0.40 min, phosphorous 0.05 max, sulphur 0.05 max. Brinell hardness is 160 min.

Grade 2H. Quenched and tempered. An excellent nut for high temperature, high pressure service. Carbon 0.40 min, phosphorous 0.05 max, sulphur 0.05 max. Brinell hardness 248 to 352.

Grade 4. A heat-treated nut, made of molybdenum steel. Ideal for unusually severe conditions of temperature and pressure. Also for sub-zero work, as it has minimum Charpy impact value of 15 ft-lb down to —150 F. Carbon 0.40 to 0.50, manganese 0.50 to 0.95, phosphorous 0.04 max, sulphur 0.05 max, silicon 0.15 min, molybdenum 0.20 min. Brinell hardness 248 to 352.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

everywhere in the petroleum industry...

FLUOR BUILDS PROCESSES INTO PROFITS

Paraphrasing the old show-business offer, "Have tux, will travel," Fluor can state: "Have experience, will go *anywhere*." Recently, for example, we completed a new 11,000 bbl/day refinery for Caribbean Refining Company at San Juan, Puerto Rico. Now playing an important part in the Commonwealth's amazing industrial development, the new refining facility helps satisfy a growing demand for petroleum products on this once basically agricultural island.

Away from the mainland like this, dependability becomes more than ever a vital feature of any construction project. Fluor's 65 years of *demonstrated* dependability is the big reason why Caribbean placed the project... from site preparation to on-stream completion... in our hands. And it's also why refiners, chemical and petrochemical producers and electric power companies *everywhere* have found that "you can be *sure* with Fluor."

FLUOR

Bridging the gap between plans and national development

SAN JUAN

A 5,000 bbl/day Fluid Catalytic Cracker (process by Universal Oil Products; engineering design by Fluor) is an important unit of the new Fluor-built plant, which also includes the most modern facilities for crude distillation, fractionation, catalytic polymerization and gas treating and blending.

Engineers • Constructors

FLUOR

The FLUOR CORPORATION, Ltd.

2500 So. Atlantic Blvd., Los Angeles 22, Calif. • Offices in Principal Cities in the United States and Canada

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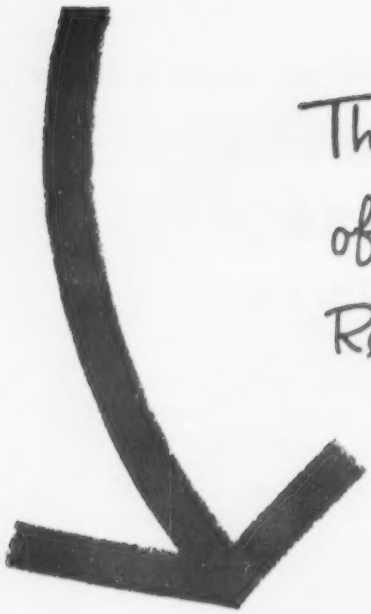
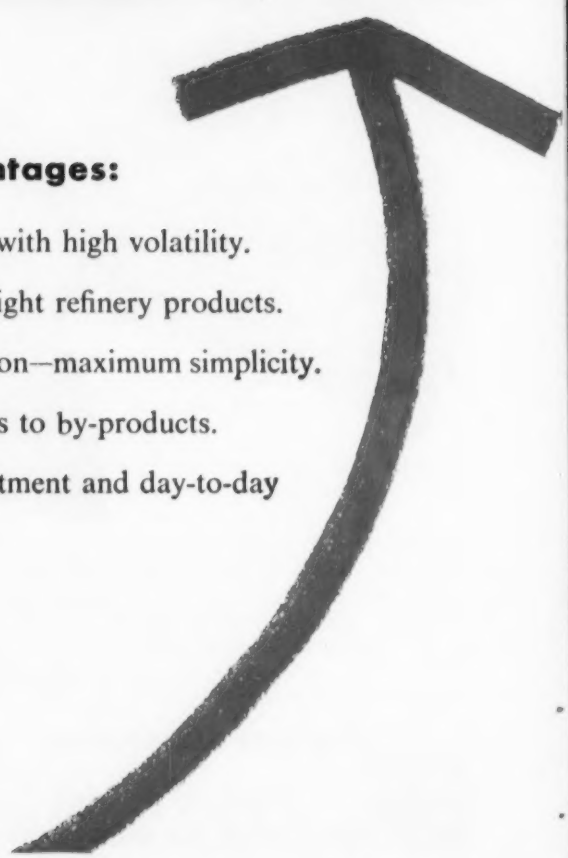


This is an announcement
of a brand new
Refining Process developed by
Universal Oil
Products Company

PEN



PENEX offers these advantages:

1. Provides a high octane product with high volatility.
2. Upgrades natural gasoline and light refinery products.
3. Affords mild, continuous operation—maximum simplicity.
4. Clean reaction—insignificant loss to by-products.
5. Economy, both in original investment and day-to-day operation.

PENEX is an entirely new refining process which enables the refiner and natural gasoline manufacturer, for the first time, economically to upgrade his pentane and hexane fractions. It is a simple, continuous process that does not require regeneration, and utilizes a fixed-bed platinum-containing catalyst.

TRADEMARK

PENEX converts the low octane straight chain pentanes and hexanes into the much higher octane iso-compounds, accomplishing this through a clean reaction with little or no loss to by-products. Unconverted portions of the feed stock are separated and recycled to provide the ultimate in octane improvement. This new process employs mild operating conditions, and the non-corrosive nature of the catalyst assures easy and long-sustained operation.

PENEX is available NOW!

PENEX is an important advancement in petroleum refining technology. It is ready to be put to work now. All refiners, everywhere, should investigate this new process fully either for early application or for consideration as part of their future planning.

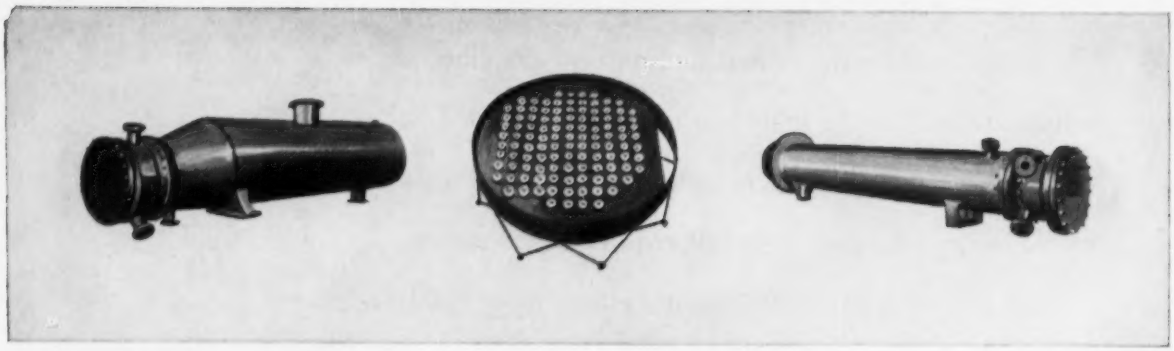
UOP®

UNIVERSAL OIL PRODUCTS COMPANY

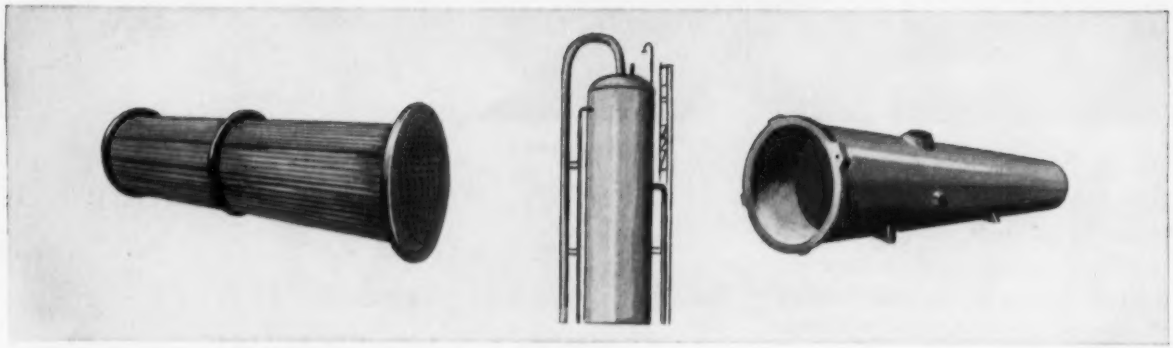
30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U. S. A.

Forty Years Of Leadership In Petroleum Refining Technology

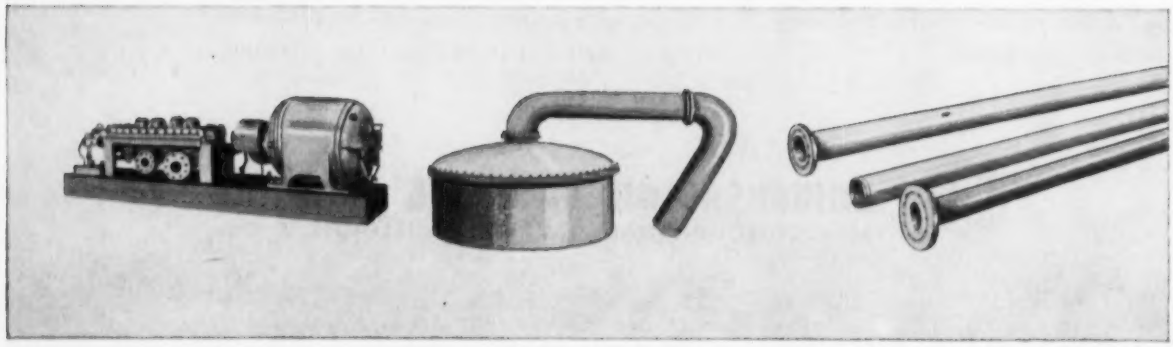
YOU CAN STOP CORROSION



ALL AROUND THE REFINERY

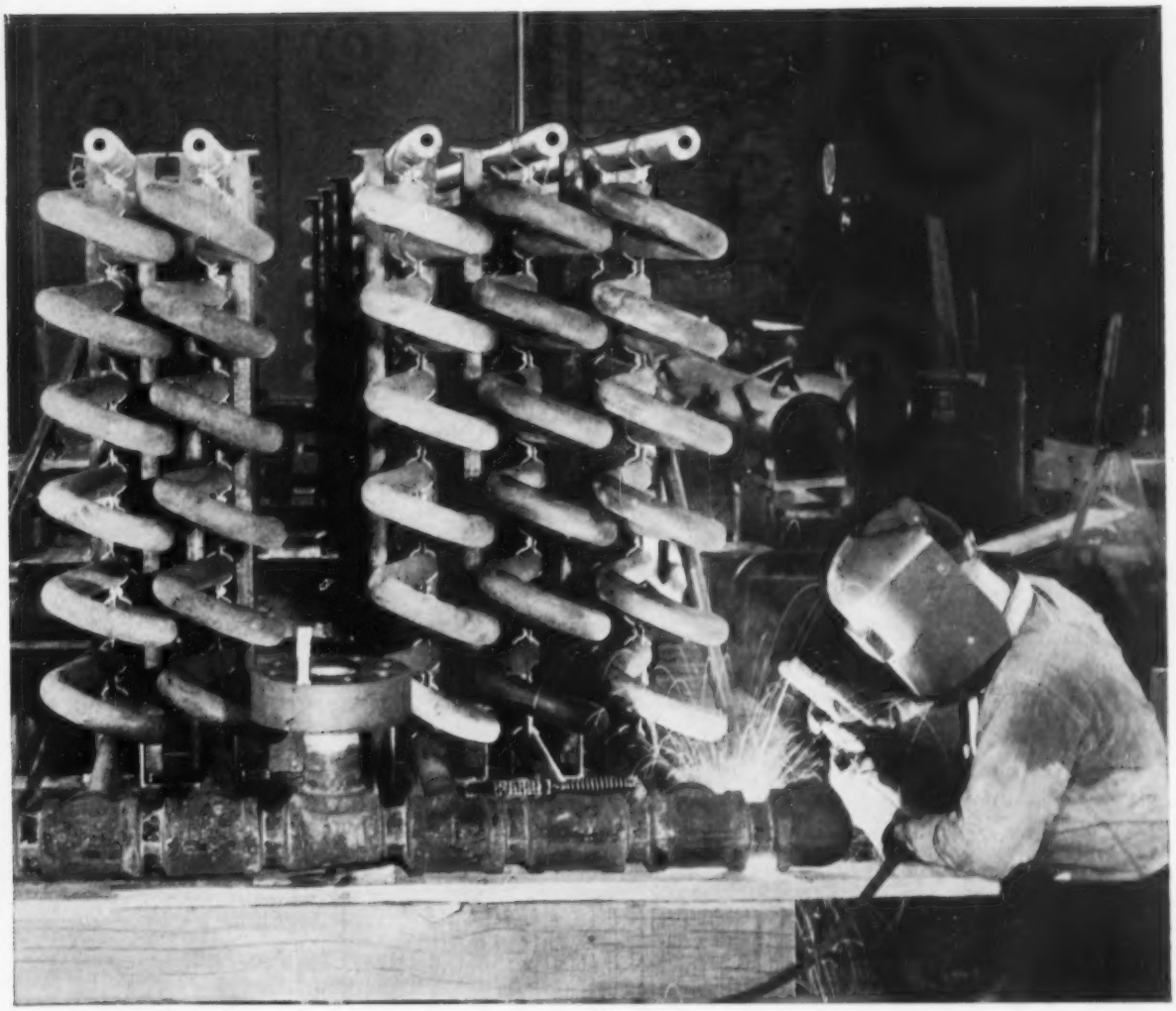


WITH POLYRAD® INHIBITOR



Pine Chemicals Division

Naval Stores Department **HERCULES POWDER COMPANY** INCORPORATED *976 Market Street, Wilmington 99, Del.*



Putting the Chill on NH_3

The Vilter Manufacturing Co. of Milwaukee, Wis., makes, among other interesting and useful products, ammonia (NH_3) synthesis coolers. These coolers must contain the newly-made hot gas at a pressure of 10,000 psi and reduce its temperature by means of cooling water conducted over the tubes.

To meet its exacting requirements, Vilter chose B&W Seamless Tubing, made for high-pressure service. All tubing in these coolers is tested at 15,000 psi.

To bend these heavy-wall tubes to a 4″ radius, 3⅛″ off the vertical plane, is evidence of Vilter's skill and craftsmanship at work.

And for evidence of how B&W tubing can help improve your own skill and craftsmanship, get in touch with Mr. Tubes, or write for Bulletin 408. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

TA6032-P

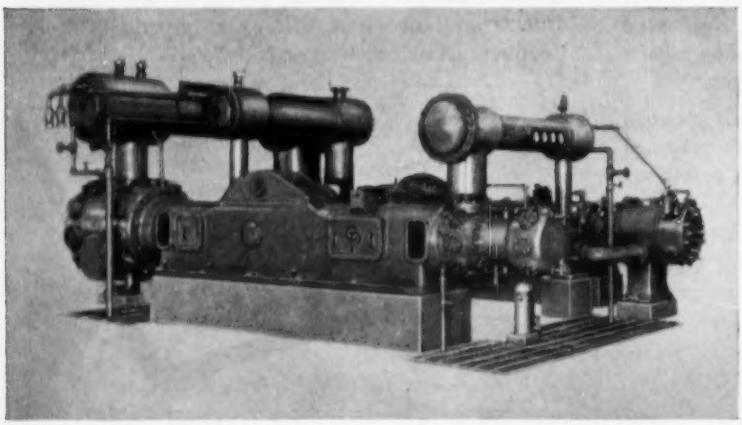
Seamless and welded tubular products, seamless welding fittings and flanges—in carbon, alloy and stainless steels

For more data on advertised products, use Readers' Service Cards, last page.

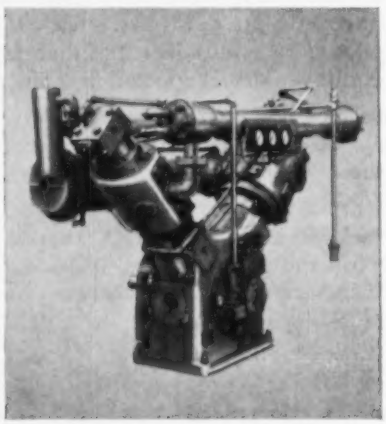
Compressors with

'round the clock dependability

H-CE horizontal "four-corner" motor-driven four-stage gas compressor.

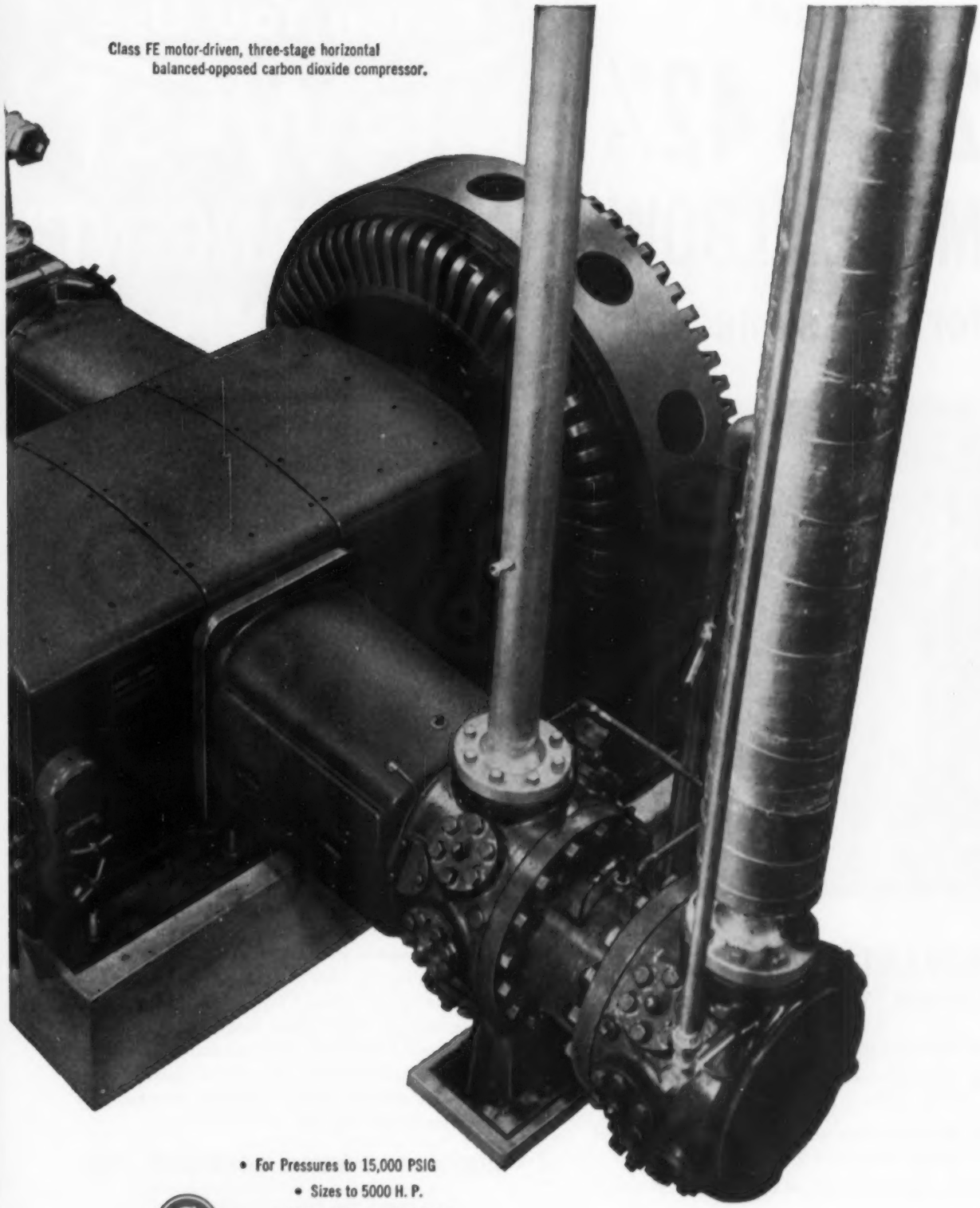


Class Y four-stage compressor for air and non-condensable gases. Ideal where floor space is limited.



For more data on advertised products, use Readers' Service Cards, last page.

Class FE motor-driven, three-stage horizontal balanced-opposed carbon dioxide compressor.



- For Pressures to 15,000 PSIG
- Sizes to 5000 H. P.
- Motor, Steam or Belt Drive

Chicago Pneumatic

8 East 44th Street, New York 17, N. Y.

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS

...you get

21% to 42% MORE ELBOW for the same cost

When You Use MIDWEST "LONG TANGENT" ELBOWS

90° LONG RADIUS LONG TANGENT
SIZES: 2" THRU 36"

90° SHORT RADIUS LONG TANGENT
SIZES: 14" THRU 36"

45° LONG RADIUS LONG TANGENT
SIZES: 2" THRU 30"

ADVANTAGES OF MIDWEST "LONG TANGENT" ELBOWS

- ★ They save pipe.
- ★ They often eliminate short nipples and their extra welds.
- ★ They save time and money in lining up and clamping pipe and fitting.
- ★ They make it easier to apply slip-on flanges.
- ★ They remove the circumferential weld from point of maximum stress and can be sleeved.
- ★ THEY COST NO MORE THAN OTHER ELBOWS.

The long tangents available *only* on Midwest Welding Elbows give you *more fitting for the same price* . . . Midwest "Long Tangent" Elbows cost no more than other elbows. This added length has numerous advantages for the user of welded piping . . . advantages that save money and improve piping. For all the facts, ask the nearest Midwest distributor or write us for Catalog 54.

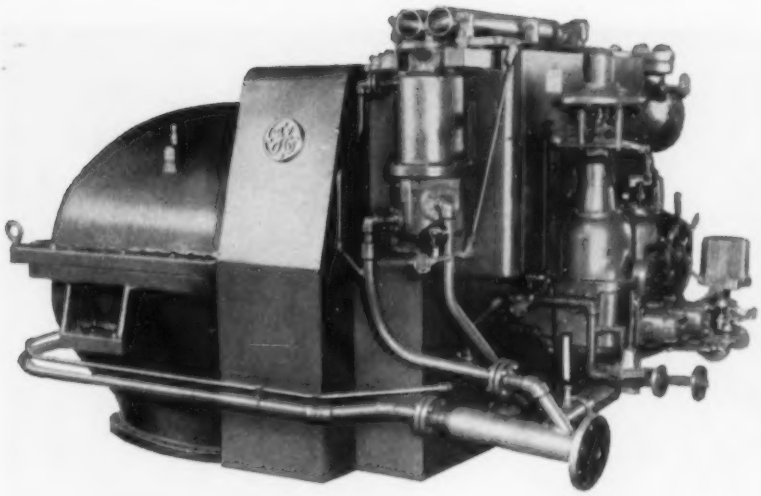
MIDWEST PIPING COMPANY, INC.

Main Office: 1450 South Second Street, St. Louis 4, Mo.
Plants: St. Louis, Clifton, N.J. and Los Angeles

Sales Offices:
New York 7—50 Church St. • Chicago 3—79 West Monroe St. Cleveland 14—616 St. Clair Ave. • Los Angeles 33—520 Anderson St. Houston 2—1213 Capitol Ave. • Tulsa 3—224 Wright Bldg. • Miami 34—2103 Le Jeune Rd. • Boston 27—426 First St.
STOCKING DISTRIBUTORS IN PRINCIPAL CITIES

MIDWEST WELDING FITTINGS IMPROVE PIPING DESIGN AND REDUCE COSTS

7324



THIS TURBINE

ROSS EXCHANGER

equal efficient, high-speed operation

This General Electric high-speed Turbine is used to drive modern compressors and blowers at 7000 rpm and up. At such speeds, thorough lubrication is obviously needed.

Factory-installed by G-E, a Ross Exchanger keeps lube oil temperature within recommended limits. As a result, gears and bearings always receive sufficient lubrication at the correct viscosity.

Rugged, dependable Ross Exchangers are components of numerous makes of turbines. In fact, they are used throughout the chemical and refining industries to control oil temperatures for engines, speed increasers, compressors, torque converters and many other types of major equipment.

Combining high thermal efficiency and extreme ruggedness, pre-engineered and fully standardized Ross Exchangers are available in a wide range of sizes to meet most requirements.

For complete detailed information, request Bulletins 1.1K5 and 2.1K5.

ROSS HEAT EXCHANGER DIVISION
of
AMERICAN-Standard
1419 WEST AVENUE • BUFFALO 13, N. Y.
In Canada: Kewanee-Ross of Canada Limited, Toronto 5, Ont.

For more data on advertised products, use Readers' Service Cards, last page.

NO FOG *with Rochester*

Hermetically Sealed Dial Instruments

Moisture, when permitted inside an instrument dial, not only fogs the dial glass but has destructive access to vital working parts inside. In addition to hard-to-read instruments, it leads to undependable performance and shorter, costlier instrument life.

Rochester Manufacturing Company developed its own hermetic dial-sealing process to completely eliminate this moisture hazard. The RMC process insures that humid air will not be sealed in the instrument and locks moisture out *permanently*.

Look to RMC for Full-Line Instrumentation

LEVEL GAUGES

Illustrated is an 8" dial, float-operated level gauge, with magnetically driven pointer, for pressure vessels. What is your liquid level gauge problem?

PRESSURE GAUGES

Illustrated is a heavy-duty compound type gauge for service on high frequency, low amplitude vibration. What is your pressure or vacuum gauge problem?

TELL US YOUR REQUIREMENTS FOR DIRECT MOUNTING AND REMOTE INDICATING INSTRUMENTS, AND LET RMC ENGINEERING SKILL PROVIDE THE ANSWERS!

Write today, outlining your particular need or problem.

RMC

"You Can Rely On Rochester"

REPRESENTATIVES IN ALL PRINCIPAL CITIES

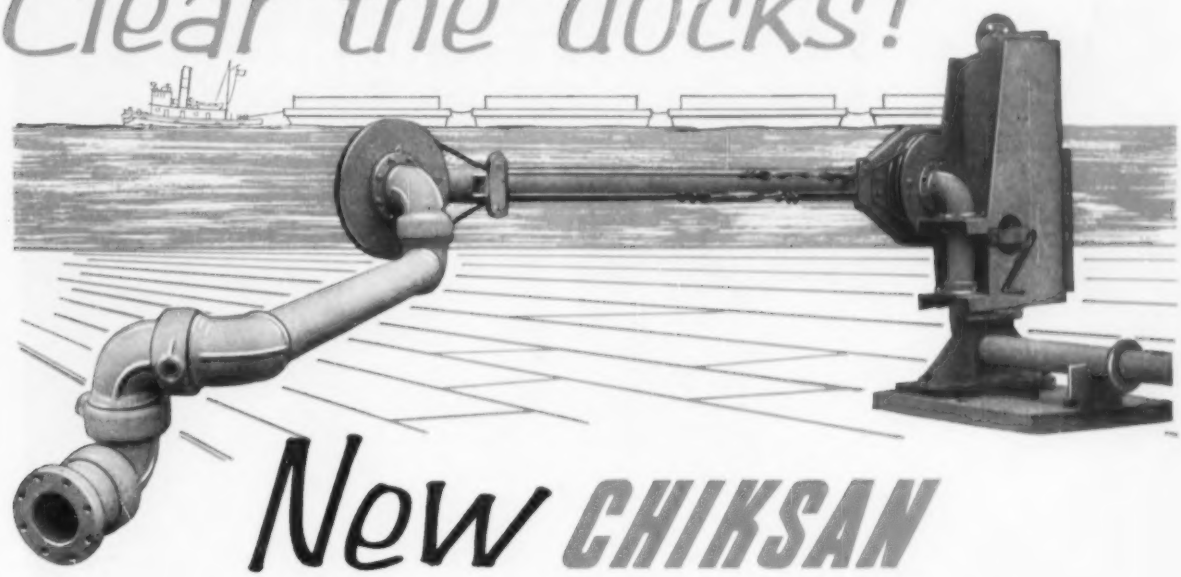
LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC.

38 ROCKWOOD STREET • ROCHESTER 10, N.Y.

FOR FAST, SAFE BARGE LOADING

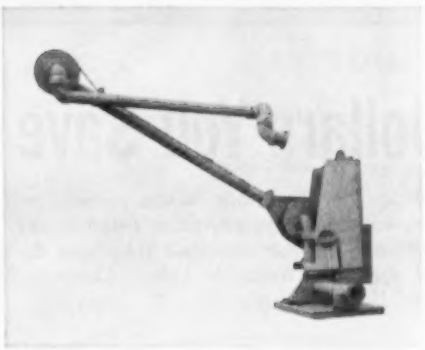
Clear the docks!



New CHIKSAN BARGE LOADING ARM

SAVES ON

Line Handling Injuries
Dock Clutter
Lengthy Hookup Time
Hose Bursts
Replacement Costs



This newly developed barge loading arm ends hazardous manhandling of loading hoses, eliminates dangerous dock clutter. Mechanical operation makes hookup fast and simple... one man can handle the job in minutes with no physical strain.

Ball bearing swivel joints make it possible to rotate the arm to meet varying flange locations. After arm is flanged to barge riser, it can be left unattended. Arm will automatically conform to the various positions of the barge as loading or unloading is carried out. When not in use the operation arm can be raised up and out of dockside traffic.

Write For Illustrated Literature, Dept. 5-5

CHIKSAN

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

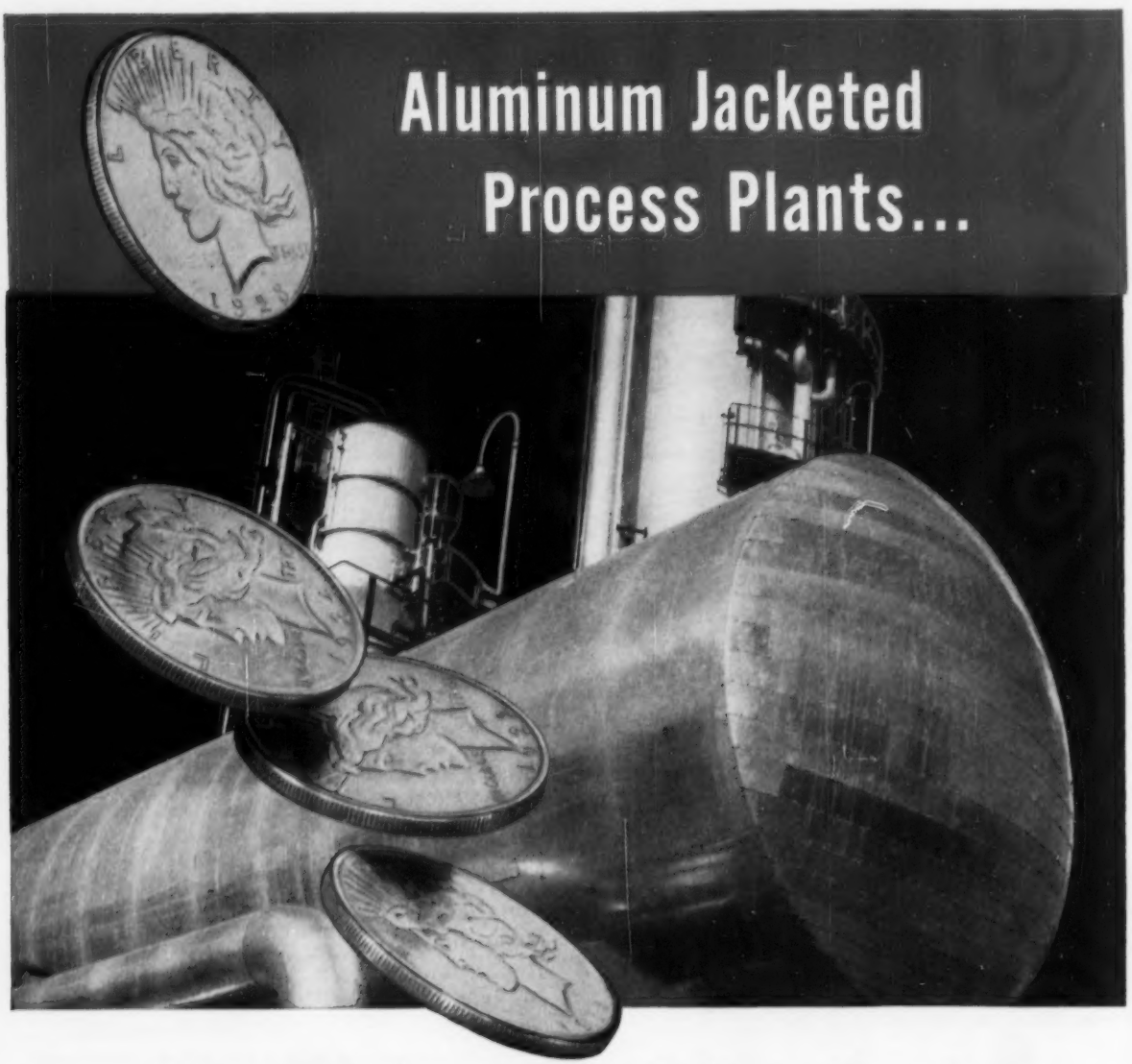
fmc

CHIKSAN COMPANY — BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division) Houston 1, Texas • Chiksan Export Company • Chiksan of Canada, Ltd., Edmonton, Alta.

For more data on advertised products, use Readers' Service Cards, last page.

Aluminum Jacketed Process Plants...



...Stay Bright as the Dollars You Save

Aluminum resists rust and corrosion due to chemicals, gases, plant atmospheres, coastal environments. You enjoy the natural "bright-as-a-dollar" appearance of this long-lasting metal. You save the expense of painting. You save many dollars on replacement of equipment often destroyed by rust and corrosion.

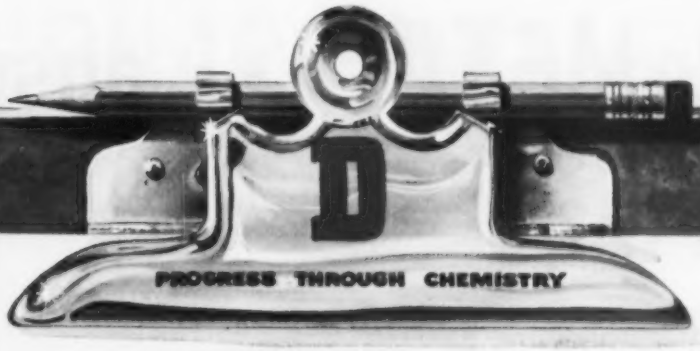
You benefit in other ways, too, with aluminum. It's non-sparking. Eliminates much of the danger of costly fires and explosions. Makes it ideal for walk-ways and tank decks.

Aluminum is versatile. You get natural insulation and high heat transfer from aluminum in many plant uses. Use it for heat exchangers, high pressure steam lines, fractioning towers and many other applications.

Wherever you use aluminum, it remains bright, lasts long, and saves you money. To get more information on aluminum in the process industries, call the Reynolds office listed under "Aluminum" in your classified telephone directory. Or write *Reynolds Metals Company, P.O. Box 1800-CT, Louisville 1, Kentucky.*

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

See "FRONTIER", Reynolds exciting dramatic series, Sundays, NBC-TV



Stability,

. . . a basic ingredient in Davison's Petroleum Catalysts

Davison achieves it through control of filament size and orientation (see illustration below). Davison catalysts possess greater mechanical strength because of their larger filament diameters. The orientation of these filaments provides a catalyst of large pore diameters.

These two factors combine to give Davison catalysts longer life through greater stability.

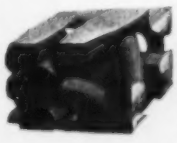
Davison has for many years been the leader in the production of catalysts. This leadership has been maintained through Davison's continuing ability to produce catalysts designed to meet the requirements of all types of fluid catalytic cracking units.

For information on Davison catalysts, see your Davison Representative, or write

DAVISON CHEMICAL COMPANY
Division of W. R. Grace & Co.
Baltimore 3, Maryland

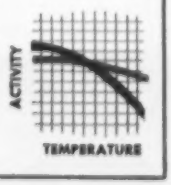
Sales Offices: Chicago, Ill.; Houston, Tex.; New York, N.Y.; Baltimore, Md.
In Canada: Davison Chemical Company Ltd., Toronto

Producers of: Catalysts, Inorganic Acids, Superphosphates, Triple Superphosphates, Phosphate Rock, Silica Gels and Silicofluorides. Sole Producers of DAVCO® Granulated Fertilizers.



Structural Stability, Catalyst in the form of submicroscopic filaments provides the surface area on which catalytic reactions take place. Large filaments give greater mechanical strength.

Thermal Stability, The graph compares high pore diameter catalysts (in blue) with ordinary catalysts. By resisting heat deactivation, high pore diameter catalysts have a higher useful activity.



For more data on advertised products, use Readers' Service Cards, last page.

DUAL METAL··· answer to

What is it ?

To thirty-one of America's largest industries with problems of abrasion or corrosion – or both –"Dual Metal" means U. S. Pipe's Steel and Tubes Division.

Specifically, "Dual Metal" is our name for centrifugally cast cylindrical sections in which two dissimilar metals are bonded metallurgically by centrifugal force and temperature.

"Dual Metal" centrifugally cast, integrally fused combinations of two dissimilar metals are doing industry's most difficult and exacting jobs better and more economically than ever before.

Design engineers have been quick to recognize the outstanding merits of a process capable of combining the desired mechanical and chemical properties no single metal possesses.

"Dual Metal" means versatility, efficiency and economy.

Research and development play a vital and important role in the centrifugal casting of "Dual Metal" combinations. Our Pilot Foundry is devoted entirely to process and product improvement.

UNITED STATES PIPE & FOUNDRY CO.

Steel and Tubes Division

STEELS AND TUBES DIVISION U S P

BURLINGTON, NEW JERSEY

SALES OFFICES: LOS ANGELES, SAN FRANCISCO, CHICAGO, ST. LOUIS, COLUMBUS, DETROIT, PITTSBURGH, HARTFORD, BURLINGTON

your TURNAROUND problems

"Dual Metal" solves one of the petroleum industry's most severe and costly problems — catalyst erosion of lift pipe and catalyst handling lines.

In making a "Dual Metal" lift pipe the outer shell of weldable alloy steel is poured into a rapidly rotating mold. The abrasion-resistant alloy iron core is introduced at the proper time and temperature. Result? A metallurgically bonded two-metal structure that combines the strength and weldability of low alloy steel and the superior abrasion resistance of alloy iron.

"Dual Metal" lift pipes are now in use in over 80 of the nation's leading refineries. In one typical refinery periodic examinations of high temperature catalyst pipes have indicated abrasion resistance of better than 16 to 1 over conventional steel piping. A once-troublesome bottleneck in processing has been eliminated and turnaround operations made shorter — a major saving of both time and money.

Perhaps this versatile process is the answer to your particular problem. Write today for specific literature and information on "Dual Metal's" applications for the refining industry.

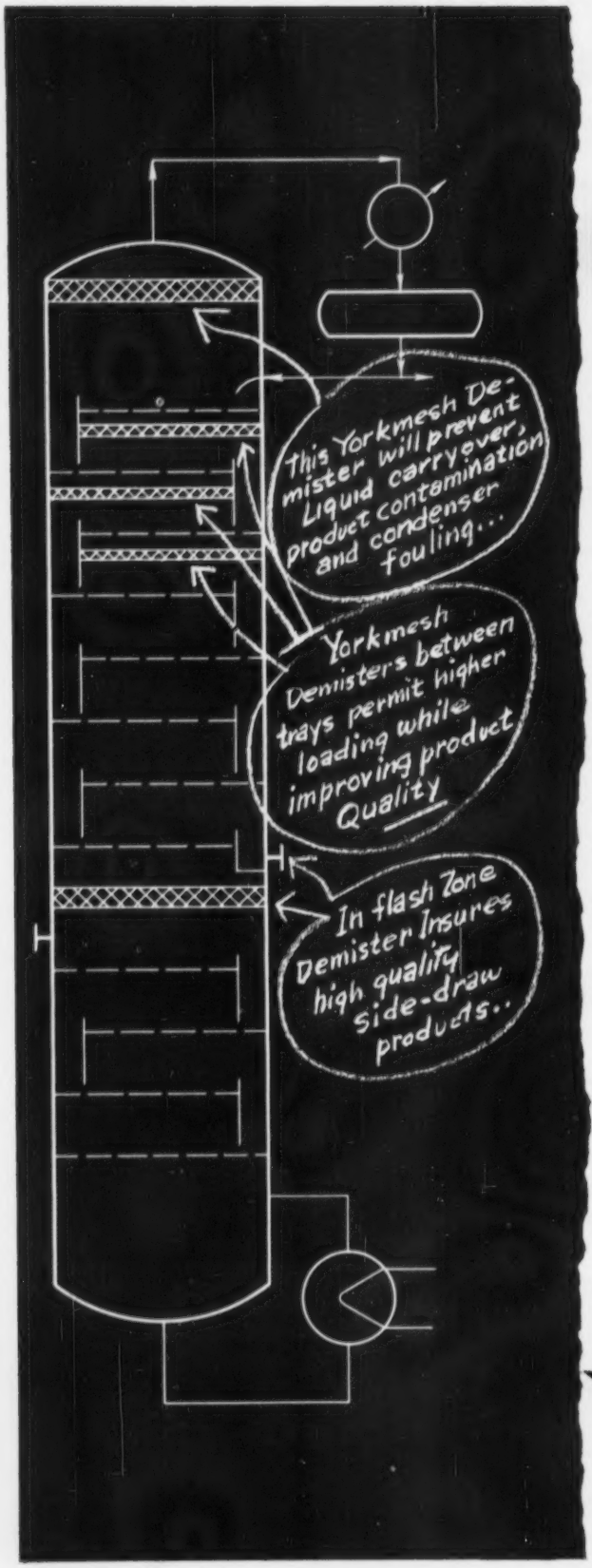
"DUAL METAL" CENTRIFUGAL CASTINGS: SIZE RANGES

OUTSIDE DIAMETER: 6" to 48" WALL THICKNESS: ½" and up
LENGTH: Up to 16 ft. without welding
TYPICAL OIL INDUSTRY APPLICATIONS: Catalyst Lift Pipe, Depressurizing Pipe, Catalyst Transfer Lines, Slush Pump Liners, Valve Nozzles, Extrusion Liners, etc.

Left. Cross-section view of dual metal piping consisting of a weldable SAE 4120 steel outer shell and a metallurgically bonded inner layer of high carbon-high chromium abrasion resisting iron. Photograph actual size. Composition of the hard inner layer:

C	Mn	P	S	Si	Cr
2.85	1.10	.009	.023	.85	29.36

Below. Photomicrograph showing the bond or fusion zone between the outer and inner metals. The mild etch required for the 4120 steel did not attack the high chromium iron. Etched — 100 diameters magnification.


This Yorkmesh Demister will prevent Liquid carryover, product contamination and condenser fouling...
Yorkmesh Demisters between trays permit higher loading while improving product Quality
In flash zone Demister Insures high quality side-draw products..

How to INCREASE THRUPUT in DISTILLATION EQUIPMENT...

The efficiency of separation and thruput capacity of distillation equipment can be significantly improved by the use of YORKMESH DEMISTERS.

Overhead quality is improved by eliminating liquid entrainment containing high boiling impurities.

Increasing thruput in existing equipment often results in decreased product quality. YORKMESH DEMISTERS installed between trays will permit increased thruput capacity while maintaining or improving quality of overhead product.

The advantages of positive separation of liquid from gas are obtained with negligible pressure drop.

Send details on your operating conditions and let YORK engineers take the responsibility of improving the performance of *your* equipment.

Similar improvements in process efficiency are effected by the clean separation of vapor from liquid in:

Vacuum Towers • Flash Tanks
Distillation Equipment • Evaporators
Absorbers • Scrubbers • Steam Drums

WRITE for Bulletin 17 and a complete list of the many case histories available from our technical library.

YORK

OTTO H. YORK COMPANY, INC.
6 Central Avenue, West Orange, N. J.

Specialists in FLUIDS SEPARATION / ENGINEERS and MANUFACTURERS

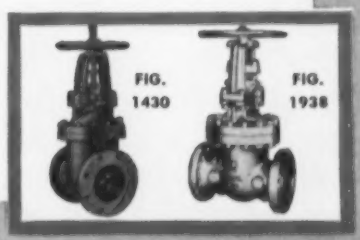
LUNKENHEIMER OPENS

New Modern IRON and STEEL VALVE PLANT

THIS 400-foot machine bay—one wing of the new Lunkenheimer plant—houses the industry's most up-to-date precision equipment for manufacturing iron and steel valves.

Here, old-world craftsmanship and attention to detail—a Lunkenheimer tradition since 1862—are combined with modern production facilities to assure the highest standards of quality. Lunkenheimer Iron and Steel Valves are world-famous for long life and low maintenance. Their shoulderless seat rings will not warp, and the gates have exclusive machined disc guides that eliminate "chatter" and reduce wear.

This entirely new iron and steel valve plant is located next to the Lunkenheimer bronze plant, which was completely modernized a few years ago in a sweeping $3 million program. Together, they give you the finest, most dependable valves that man can build or money can buy. The Lunkenheimer Co., Box 360, Cincinnati 14, Ohio.



L-456-29

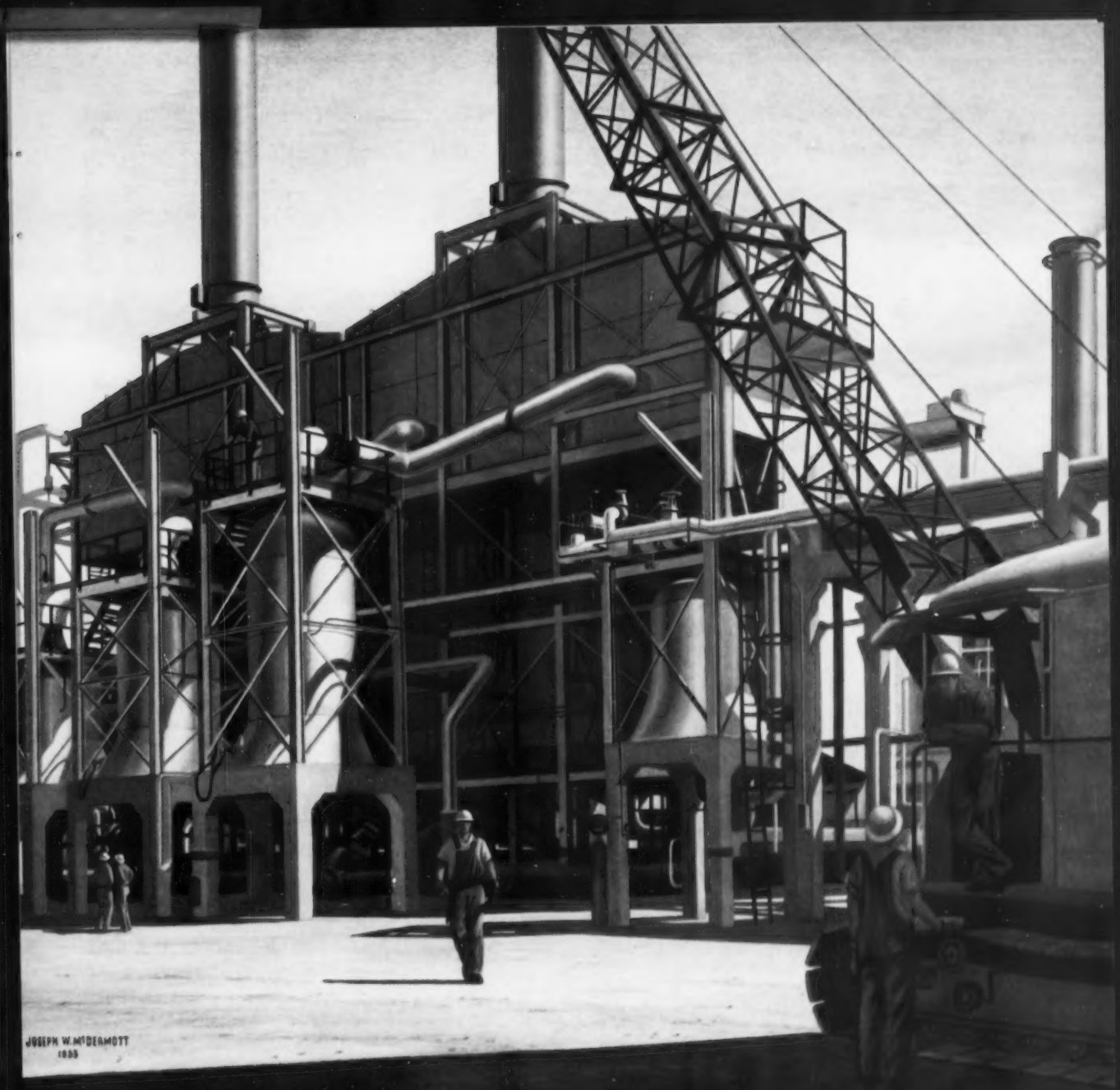
STEEL • IRON • BRONZE • PVC

LUNKENHEIMER®

THE ONE Great NAME IN VALVES

For more data on advertised products, use Readers' Service Cards, last page.

ARTISTRY
IN STEEL···
stainless
alloy
clad
carbon
oil refining and chemical
plant equipment—
fractionating towers,
pressure vessels—
plate work—
special machinery—
heavy industrial equipment—
stainless steel
Skill with the torch, or any of a hundred different tools of the trade—in steel fabrications, massive or small—is fairly obvious in the quality of the finished product. The extra touch of Sun Ship's professional skill—acquired through years of countless difficult jobs—adds artistry ...which is evident in product performances and dependability beyond the demands of industry.
Sun
SHIPBUILDING & DRY DOCK COMPANY
SINCE 1916
ON THE DELAWARE • CHESTER, PA.



THE OHIO OIL COMPANY

The new Houdriformer of The Ohio Oil Company is the first catalytic reforming unit to incorporate regeneration facilities as an integral part of the basic design. Although the need for regeneration is infrequent, the catalyst in all three reactors can now be regenerated in-place.

This Houdriformer is also equipped with a "guard case" reactor as an integral part of the main unit. The "guard case" desulfurizes the charge stock as well as reducing other contaminants and eliminating pre-treating.

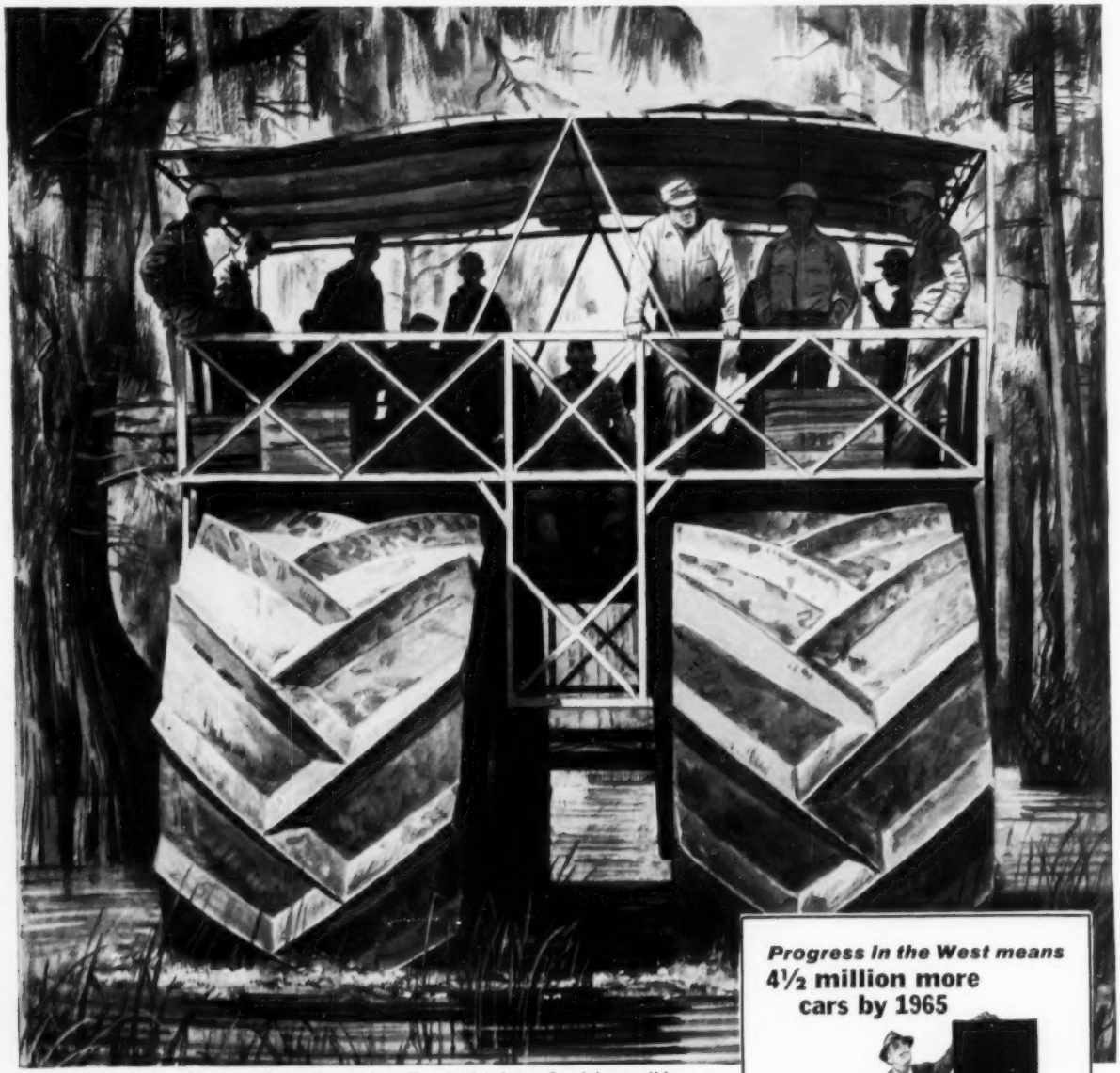
On stream at Robinson, Illinois, this Ohio Oil Company Houdriformer is an 8330 BPSD unit designed primarily for the production of high octane motor fuels. A Houdriforming brochure is available; for your copy, write to: Houdry Process Corporation, 1528 Walnut Street, Phila. 2, Pa.

HOUDRY

PROCESS CORPORATION

Pioneer in Catalytic Processes

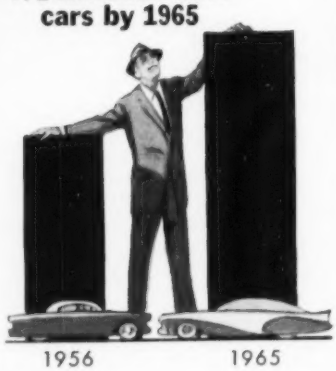
Standard is exploring 40 countries* to keep America's oil reserves the highest in history



Specially designed "swamp buggy" carrying oil geologists into a Louisiana wilderness

SWAMP BUGGIES, snowmobiles — even helicopters — are used by Standard's geologists, who seek petroleum throughout the free world and in 33 U.S. states. Our search never ends. Last year, in the Western Hemisphere alone, Standard invested $134 million in exploration, drilled 107 test wells. We added nearly three times as much oil to reserves as we brought from the ground. But U.S. consumption rises steadily. It's now over 9 million barrels *per day* and expected to increase ⅓ within 10 years. So in 1956 we'll again invest many millions in exploration, drill scores of new wells—seeking the oil you'll use tomorrow.

**Progress in the West means 4½ million more cars by 1965*



** Includes operations of affiliated companies in the Eastern Hemisphere*

STANDARD OIL COMPANY OF CALIFORNIA

puts petroleum progress to work for you

For more data on advertised products, use Readers' Service Cards, last page.

Now

LOWEST COST APPROVED LIGHTING SYSTEM! New Crouse-Hinds Type EVA Fixtures cost less to buy, install and maintain. No special installation or maintenance operations required. No pressure switch to fail and possibly create a hazardous condition. You'll get sustained performance at top economy with these new lighting fixtures. 200 W: with or without guard or reflector; overall length, 13-3/16".

Complete, explosion-proof lighting installations for acetylene & hydrogen areas!

CROUSE-HINDS CONDULETS®

UL Approved for Groups A and B Locations

- The first complete lighting system designed and UL-approved for Class 1, Groups A & B hazardous locations.
- New lighting fixture can be re-lamped even in the presence of combustible gases: gas-tightness not required for its safe performance.
- Heavy, shock-resistant construction withstands pressures from internal explosions without rupturing.
- Flame-tight joints prevent escape of flame to flammable atmosphere.

Whether you're installing a complete explosion-proof lighting system – or merely converting a few of your Group C or D fixtures to these safer Group A's – Crouse-Hinds provides greatest safety and economy. See your Crouse-Hinds distributor, or write us.

Explosion-proof Tumbler Switch Condulets

Explosion-proof Junction Condulets

Explosion-proof Sealing Condulets

Explosion-proof Flexible Couplings

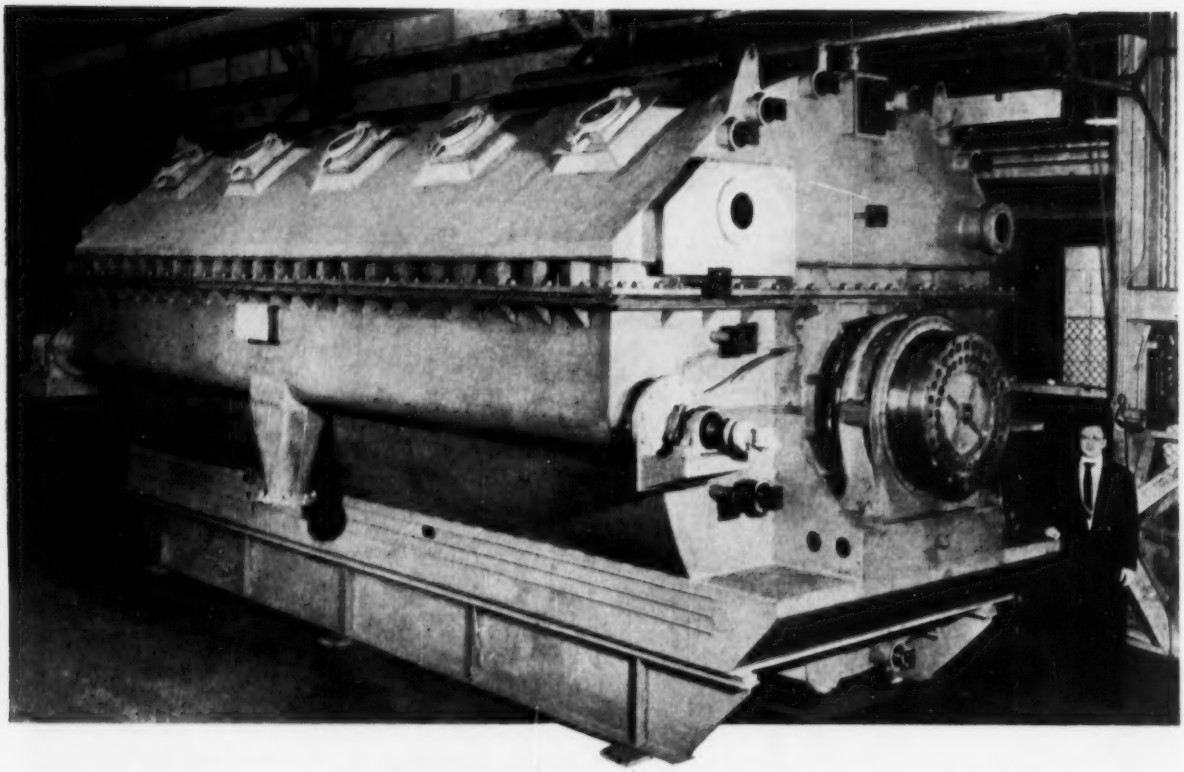
Explosion-proof Conduit Unions

A NATIONWIDE DISTRIBUTION exclusively through ELECTRICAL DISTRIBUTORS

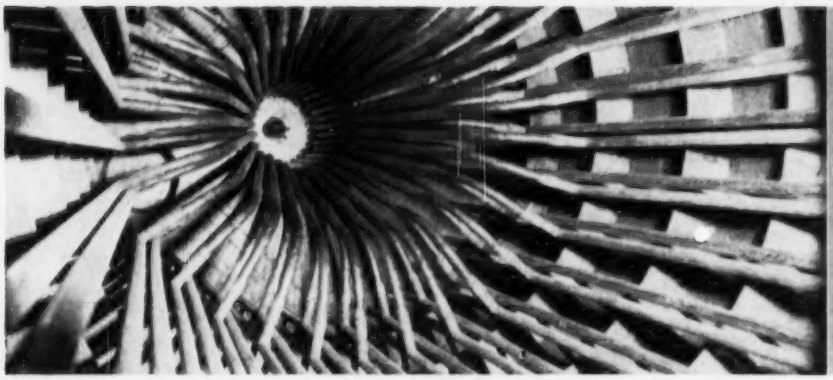
CROUSE-HINDS COMPANY

SYRACUSE 1, N. Y.

CONDULETS • FLOODLIGHTS • TRAFFIC SIGNALS • AIRPORT LIGHTING



World's LARGEST Petroleum Filters



One of six of the Oliver De-waxing Filters.

Internal drum exposure showing the pipes leading from the filter sections to the automatic valve in the trunnion.

Manufactured for a large mid-western refinery, each of these six MEK Oliver De-waxing filters measures 10′ in diameter, 22′ 3″ in length and has a filtering area of 700 square feet.

Oliver De-waxing Filters were selected for this installation because of large process capabilities, unique filtrate valve design, and a well-engineered internal drainage system.

Dorr-Oliver manufactures a complete line of filters for the petroleum industry. Other "World's Largest" . . . an Oliver pre-coat installation for breaking slop oil emulsions . . . and filtration stations for contact clay removal from lube stocks.

If you'd like more information on Oliver Petroleum Filters write Dorr-Oliver Incorporated, Stamford, Conn.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U.S.A.

For more data on advertised products, use Readers' Service Cards, last page.

TYPE 657A

Double port globe body for conventional service. Also supplied single port where tight closure required. Normally supplied in iron or steel in sizes ½" thru 12".

TYPE 657YY

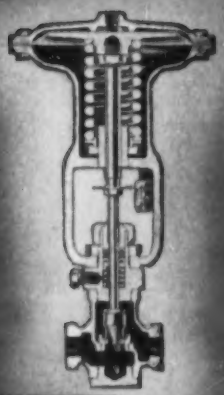
Three-way control valve for by-pass or blending service. Eliminates need for two globe type control valves. Available all castable alloys sizes ½" thru 12".

FISHER

Has the control valve for your plant

TYPE 667Z

Split type body in which parts are readily accessible; can be economically supplied in various alloys for corrosive service. Available in flanged sizes ½" thru 2".



TYPE 510G

Small and compact bronze control valve for relatively light service. Available in screwed sizes ½" thru 2".

TYPE 657-458

Angle control valve for handling fluids containing solids, or flashing liquids which are erosive. Normally supplied in steel flanged ends in sizes 1" thru 6".

TYPE 657-SAUNDERS

Fisher operator on Saunders patented valve is widely used on "hard to handle" fluids which are viscous and/or corrosive. Available in wide variety of materials in sizes ½" thru 6".

Special design bodies for process services

Wide selection of sizes and available in all castable alloys

Supplied with improved diaphragm operator that provides accurate valve response

FISHER GOVERNOR COMPANY • MARSHALLTOWN, IOWA

CANADIAN PLANT: WOODSTOCK, ONTARIO

LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.

IF YOUR PROCESS CHANGES THIS AFTERNOON

You can start a new process in 30 days!

An unusual plan is now in effect to quickly help you throw production into high gear—even on a new process.

Standard designs of reaction kettles, tanks, heat exchangers and other Pfaudler equipment have been worked out to include many of the most-wanted features of custom-built equipment, such as a variety of openings on reactor heads, and removable tube bundles in heat exchangers.

A stockpile of these standard-design units is built up, enabling Pfaudler to quickly meet your needs for standard equipment.

Same reactor used for several products

Schenectady Resins Division of Schenectady Varnish Co., Inc., makes several different resins, all of which share a common trait: no contamination can be tolerated. Dielectric properties, faithful color control and shelf life (particularly in adhesives) are endangered when metallic contamination finds its way into a batch. The equipment must also be changed over from one process to another, with a minimum of downtime.

To meet this situation a 3700-gallon Pfaudler glassed steel reactor was installed and proved to be the ideal solution.

It adapts in a matter of minutes from one product to another because few changes are necessary. The reactor itself, protected by its acid-alkali-resisting glassed interior, provides maximum flexibility.

Through new dispersion nozzles in the kettle, processing has been increased up to 25%; temperature limits up to 350° F. If you have a problem in corrosion which requires such flexibility in processing, we suggest you write for Bulletin 860-T.

Easily accessible openings, plus unusual resistance to corrosion by a variety of products, help Schenectady Resins put out top-grade resins, at a fast clip.

HEAT and COOL without CORROSION

You can increase the speed of heating or cooling in your petro chemical equipment, even under highly acid conditions.

Available for use in reaction kettles or other vessels (as well as heat exchangers) is the Pfaudler tantalum tube bundle, shown at right installed in a stainless steel reactor.

This unit gives you a new high range of corrosion resistance, because it is inert to all acids except hydrofluoric, even in high temperature or pressure conditions.

The unique characteristics of tantalum have often been found to be an excellent complement to the corrosion resistance of glassed steel or the other alloys, providing extra protection as needed in the tubes themselves.

Your Pfaudler representative will gladly explain how you may use this valuable tool to reduce corrosion, and lower your maintenance costs.

Corrosion costs the petroleum industry over a billion dollars annually. Minimize corrosion with glassed steel in combination with tantalum, titanium and other alloys.

Escambia Bay's plant near Pensacola, Fla.

This "baby" grew straight into long pants!

If the employees of Escambia Bay Chemical Corp. ever decide to honor their founder with a statue, they'll pose quite a problem for the sculptor.

For Escambia Bay was founded in October 1954 as a joint venture of three progressive companies—United Gas Corp., Electric Bond and Share Co., and National Research Corp.

Less than two years old, Escambia Bay has quickly outgrown its infancy with a multi-million-dollar nitrogen plant not far from Pensacola, Fla.

This year, it is launching into the PVC industry with a multi-million-dollar plant to produce 30 million pounds per year.

Behind this move is the combined skill and experience of UGC, Ebasco, NRC and Escambia Bay's own personnel.

Recognizing the hazards of corrosion and contamination in the processing of PVC, they have left no stone unturned to provide their new plant with the best equipment to: (1) resist corrosion, (2) protect color and purity of product from metallic contamination, (3) clean easily and at low cost, (4) discourage adherence by the sticky products involved, and (5) provide means of accurate temperature control.

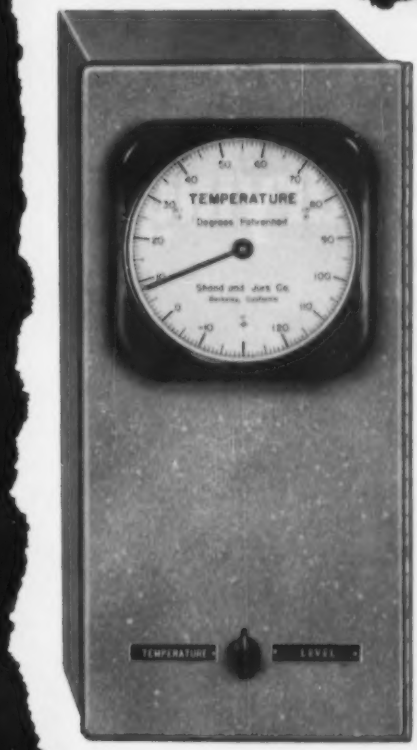
Pfaudler acid-alkali-resisting glassed steel was chosen as the most suitable material of construction for this corrosive, "sticky-product" application. Many 3700-gallon glassed steel reactors are being fabricated by Pfaudler for this modern new plant.

NOW — S&J ADDS TEMPERATURE TO TELEPULSE

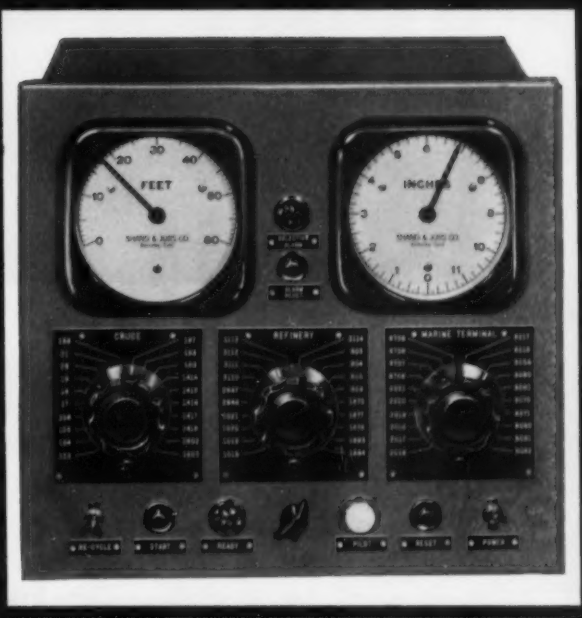
S. & J. Engineers have perfected a Telepulse Temperature System by which temperature readings may be taken of petroleum storage in distant tanks, either spot temperatures at given points of a tank, or an average temperature reading at any given liquid level.

Those who now use the famous S. & J. Telepulse Remote Reading Gaging System may add the Telepulse Temperature System as an independent auxiliary. Those not interested in level determinations may utilize the Telepulse Temperature System in obtaining remote temperature readings only.

The New Telepulse Temperature System is illustrated and described in Bulletin TT-456, while the Telepulse Remote Reading Gaging System is covered in Bulletin T-455. Please write for a copy of either or both bulletins if you are seriously interested in Remote Readings of levels or temperatures.



Above, the Telepulse Temperature Indicator, encased in a steel cabinet finished in crackle grey and of dimensions to mate perfectly with the Telepulse Level Reading Unit in size and finish, so that both may be installed side by side in an instrument panel.



The illustration at the left shows the Telepulse Remote Reading Gaging System, which gives accurate tank gage readings of distant storage in feet, inches and eighths of inches.

Shand and Jurs Co.
BERKELEY 10, CALIFORNIA

NEW YORK
342 Madison Ave.

HOUSTON
M & M Bldg.

TULSA
Thompson Bldg.

CHICAGO
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LOS ANGELES
6399 Wilshire Blvd.

REPRESENTATIVES:
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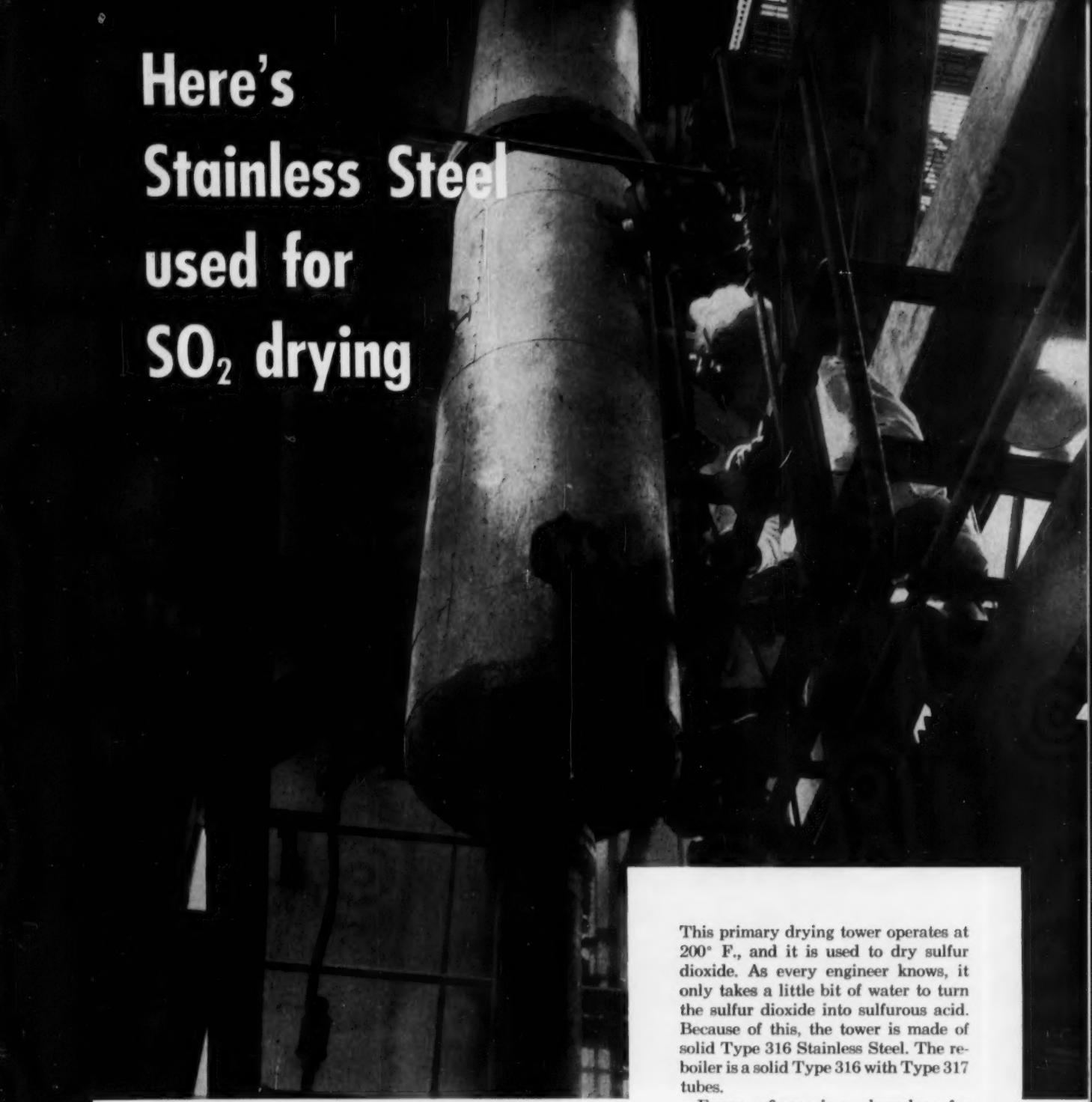
MONTREAL: Lytle Engineering Specialties, Ltd., 360 Notre Dame St., W.
TORONTO: Lytle Engineering Specialties, Ltd., 69 Eglinton East
VANCOUVER: P. D. McLaren & Son, Ltd., 3277 Main Street
CALGARY: P. D. McLaren & Son, Ltd., 510 - 9th Ave. W.
MEXICO, D.F.: Dalmar Comercial, S. A.
CARACAS: Sinclair Spence, C.A., Edificio Galipan
ENGLAND: Whessoe, Ltd., Sales: 25 Victoria St., London S. W. 1
Whessoe, Ltd., Works: Darlington, County Durham

For more data on advertised products, use Readers' Service Cards, last page.



Here's Stainless Steel used for SO_2 drying

Continental Oil Refinery No. 3, Lake Charles, Louisiana

This primary drying tower operates at 200° F., and it is used to dry sulfur dioxide. As every engineer knows, it only takes a little bit of water to turn the sulfur dioxide into sulfurous acid. Because of this, the tower is made of solid Type 316 Stainless Steel. The reboiler is a solid Type 316 with Type 317 tubes.

Every refinery is a showplace for Stainless Steel, because no other metal combines so many desirable properties. When *designing* with Stainless Steel, remember that United States Steel can furnish a greater variety of grades, types, sizes and finishes of Stainless Steel.

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

USS SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE SPECIAL SECTIONS

UNITED STATES STEEL

You can do it CHEAPER with UTILITY Electric Power

Refineries. Petrochemical Plants. Field Processing Plants - they all use Utility Electric Power

because Electric Power is flexible . . . compact . . . dependable . . . safe . . . clean . . . and can be installed at a Low Capital Investment, with LOW COST operational advantages, plus many other money saving features, including convenient automatic control.

Petroleum Electric Power Association

P. O. BOX 2771, DALLAS, TEXAS
ORGANIZED IN THE INTEREST OF GREATER SERVICE TO THE PETROLEUM INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.

CERAMIC BALLS for thermal pyrolysis and catalyst support beds

As a heat transfer and catalyst support medium in various refinery operations, "U.S." Ceramic Balls are proving unusually effective. They are being widely used in the field of pyrolysis and in catalytic reforming installations.

"U.S." Ceramic Balls possess heat-shock resistance, great crushing strength, superior thermal conductivity and high specific heat. The material is thoroughly vitrified, inert and is particularly recommended for its proven resistance to erosion and abrasion.

The smooth surface and spherical shape of "U.S." Ceramic Balls have proven more efficient than irregularly sized and shaped heat transfer elements. A special body ("CERATHERM-550") is available where exceptional thermal-shock and heat-resistance characteristics are required.

All sizes are available from 1/4" O.D. to 3" O.D.

127E

CHEMICAL CERAMICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

60 East 42nd St. New York

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customer reports prove

Big Savings with . . .

OCECO V-130 Conservation Regulators

Exclusive construction assures tight leak-proof closure fully up to operating setting — quick opening — and extremely high flows even at low pressures.

Oceco V-130 Conservation Regulators provide **greater flow capacity**, size for size, and pressure for pressure, **specially at low pressures** than **ever available before.** Our exclusive construction prevents vapors from escaping at less than set operating pressures. Positive flexing action of the membrane, held under tension, peels off and breaks away any icy formations, preventing freeze-ups. These valves bring never before secured **all weather** economy and dependability to the conservation of volatile products stored in cone, round, flat, lifter or expansion roof tanks. **Write for Bulletin No. 522. It gives full details!**

PRESSURE BALANCED CONSTRUCTION.

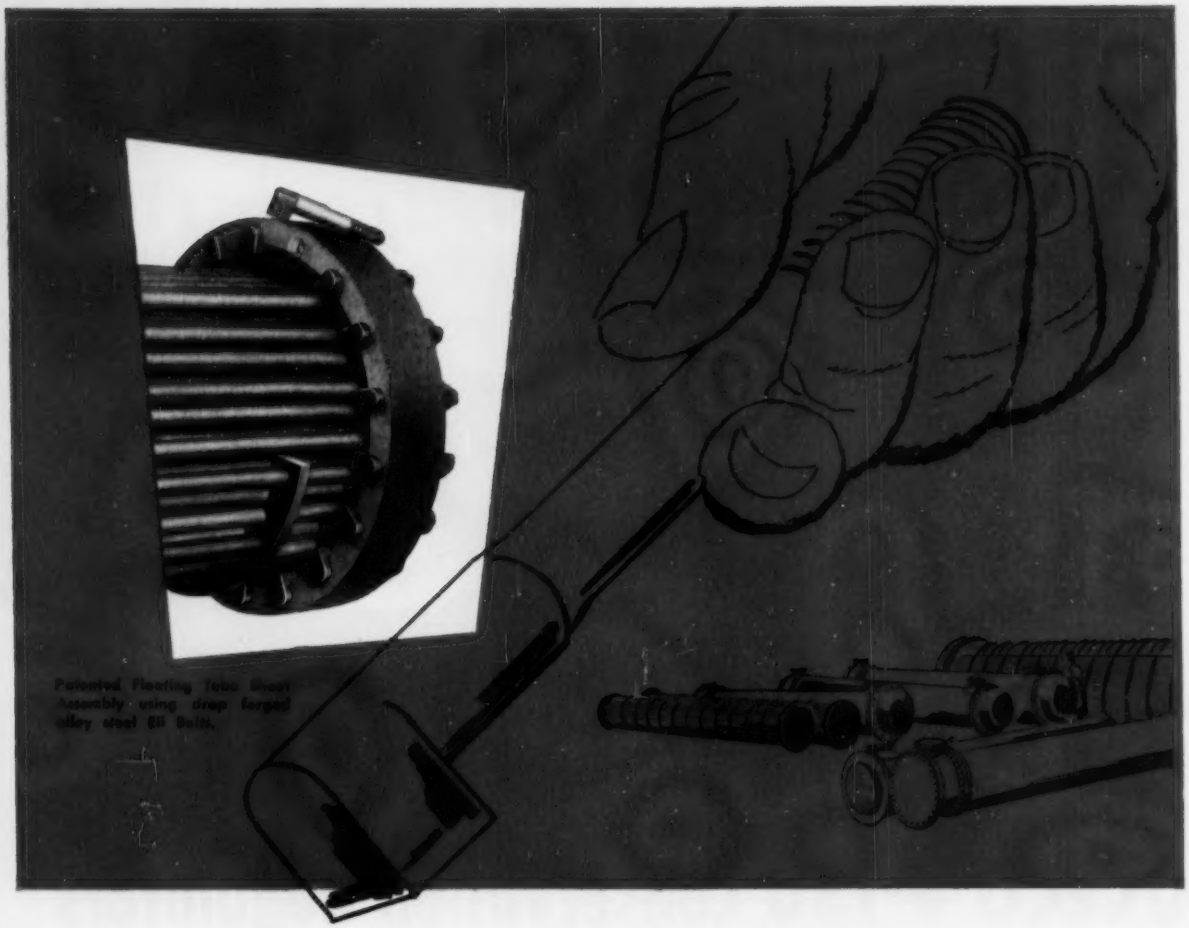
Tank pressures exerted on both sides of the pliable heat and cold resistant membrane keep membrane always under tension; —assuring tight seating fully up to operating setting— and positive flexing action that peels away icy formations preventing freeze-ups.

EXCLUSIVE OCECO FEATURE SAVES YOUR VAPOR DOLLARS!

THE JOHNSTON & JENNINGS CO.

4700 West Division Street • Chicago 51, Illinois

***Division of* PETTIBONE MULLIKEN CORPORATION**



This Ell Bolt is the Key to leak control

The patented Ell Bolt construction employed on Vogt floating head heat exchangers is the answer to re-assembly without distortion or leak development.

Cover may be removed by simply loosening the Ell Bolt nuts and disengaging the Ell Bolt heads from the "lock notches." No misplacing of Ell Bolts can result — and tightening is easy and positive — absolutely leak proof. Send for Bulletin HE-6. Address Dept. **24 XPR.**

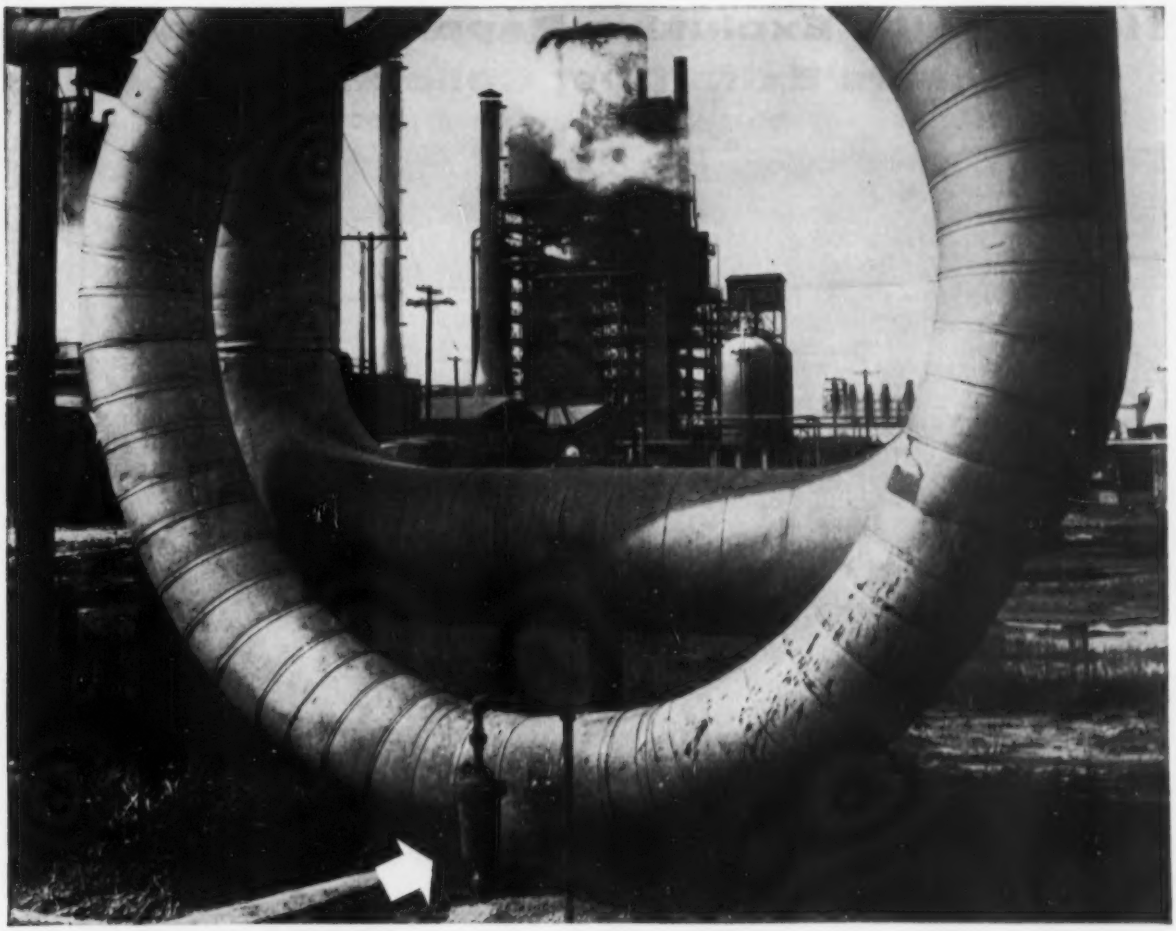
Vogt

HENRY VOGT MACHINE CO., P. O. BOX 1918, LOUISVILLE 1, KY.

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va., Cincinnati, San Francisco

OTHER VOGT PRODUCTS
Drop Forged Steel Valves, Fittings and Flanges in a complete range of sizes • Petroleum Refinery and Chemical Plant Equipment • Steam Generators • Heat Exchangers • Ice Making and Refrigerating Equipment.

HEAT TRANSFER EQUIPMENT



Look Ahead When You Specify Steam Traps...

100 or 1,000 or 10,000 steam traps in a plant are a small item in relation to the processing equipment that depends upon them. But if they are troublesome, headaches are just multiplied by the number in use. It hardly pays, then, to be pennywise in specifying traps.

Perhaps the biggest single consideration in choice of traps should be their long-range performance. Look ahead—will the traps do the job? Will they stand up? Will they require frequent maintenance?

No traps in the world have ever turned in better performance records than Armstrongs. And, here is why:

Design—simple...only two moving parts . . . "frictionless" free-floating leverage . . . heavily reinforced for wear . . . generous safety margins.

Materials—file-hard chrome steel valve and seat, hardened, ground and lapped together. All other parts corrosion-resistant stainless.

Experience—designed and built by men with more inverted bucket trap experience than any other organization.

Inspection—quality control is not by sampling—*every trap* is tested before shipment.

Guarantee—satisfaction or your money back.

When you specify Armstrong traps you can look ahead to long, long trap life with infrequent maintenance. Ask your Armstrong Representative to give you details or write:

ARMSTRONG MACHINE WORKS
852 Maple Street, Three Rivers, Michigan

Application Engineered

ARMSTRONG STEAM TRAPS

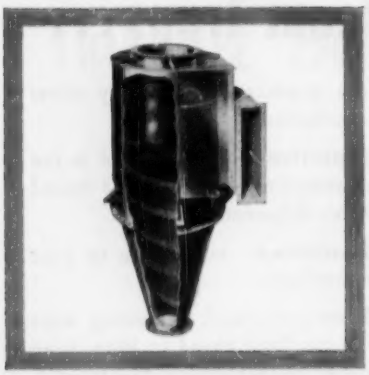
ASK FOR STEAM TRAP BOOK

. . . 44 pages of practical data designed to give you better trapping. Free on request . . . no obligation.

575

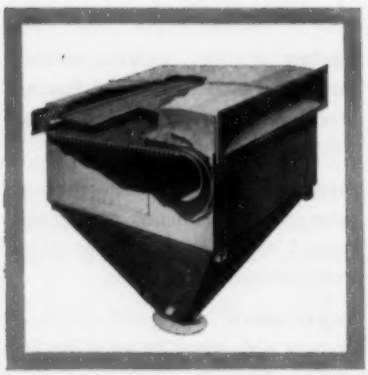
How Buell's Exclusive Rapping Mechanism delivers Extra Dust Collection Efficiency

ORDINARY RAPPING
Shakes dust from collecting electrodes. Re-entrainment of cloud of dust reduces precipitator efficiency
BUELL RAPPING
Shears dust from collecting electrode surface, minimizes scattering and re-entrainment



Buell Cyclones offer two "extra-efficiency" advantages: (1) exclusive Shave-off which harnesses double-eddy and puts it to work, and (2), large diameter design which eliminates clogging.

Complementing the extra efficiency of rapping in Buell "SF" Electric Precipitators, the unique Spiralectrodes add further efficiency through 50% to 100% higher electron emission, constantly accurate spacing, longer electrode life.



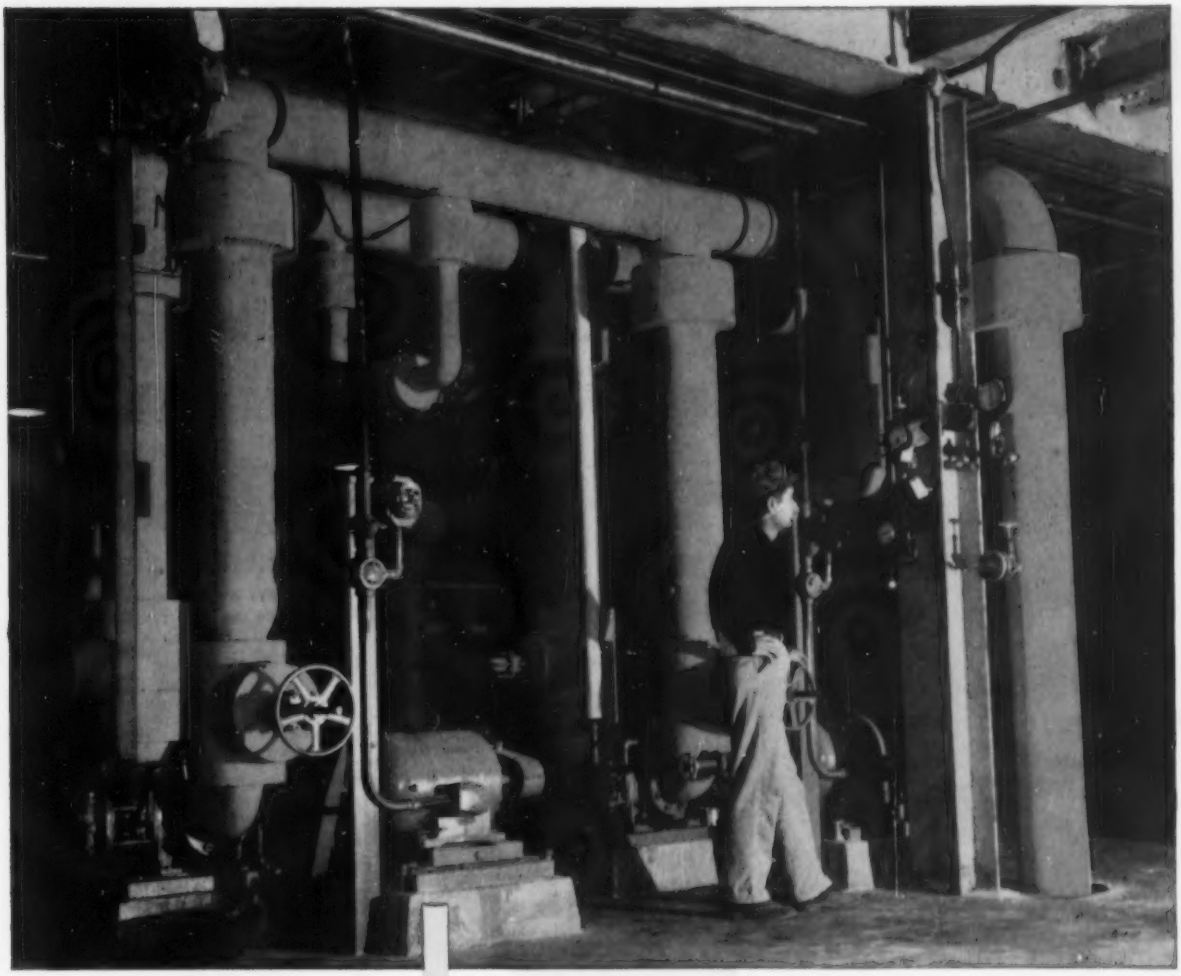
Buell's Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for natural or forced draft installations. Ideal for boilers from 100 to 2000 BHP.

For more specific data about Buell's *extra efficiency*, write Dept. 50-E, Buell Engineering Company, 70 Pine Street, New York 5, N. Y.

buell®

MECHANICAL ELECTRICAL

Experts at delivering Extra Efficiency in **DUST COLLECTION SYSTEMS**



Specify GUSTIN gb BACON SNAP*ON *for good and fitting reasons*

Plant piping takes on this trim, tailored look — and in record time — when you insulate with G-B Snap*On, the one-piece molded pipe insulation of fine glass fibers. From ¾" through 33" IPS and in 3' and 6' sections depending on pipe size. With just a pocket knife and a stock of Snap*On in nesting sizes, *anyone* can make easy work of the once-tedious job of insulating bends, valves and other fittings.

To fully understand why this material saves so much time and money on fittings and straight runs you need only handle a 6-foot section of Snap*On. It's flexible, yet resilient. It's feather-light, yet tough. It's almost impossible to damage, yet easy to cut with a knife. And to these obvious advantages, you can add such unseen benefits as *permanence* and the *highest thermal efficiency of any pipe insulation on the market.*

Next time you have hot or cold piping to insulate, call your nearby distributor, listed in the Yellow Pages under "G-B Insulations." In the meantime, write today for our new 8-page brochure with full details on "the first all-new pipe insulation in 60 years."

GUSTIN-BACON *Manufacturing Company* GUSTIN gb BACON

Thermal and acoustical glass fiber insulations • Pipe couplings and fittings • Railroad gaskets and supplies.

242 W. 10th St., Kansas City, Mo.

For more data on advertised products, use Readers' Service Cards, last page.

Bingham

"KOKE-KRUSHER" HOT OIL PUMP

NON-CLOGGING!

PULVERIZES LARGE PIECES OF ENTRAINED COKE IN PUMPAGE

Bingham Type CKM
"Double Volute", Two Stage,
"KOKE-KRUSHER" for handling
hot, coke-laden pumpage at high heads.

CRUSHES COKE INSTANTLY

Positive crushing mechanism instantly crushes large pieces of hard coke entrained with the pumpage.

- Results in more hours on stream—less down time.
- The pulverizing action on entrained solids reduces clogging of other system equipment.
- Non-pulsating flow eliminates need of auxiliary equipment for control of pressure and/or capacity.
- Eliminates expensive protective devices.
- Smooth pump characteristics eliminate destructive vibration.
- Lower maintenance. Only one moving part.

HANDLES COKE-LADEN HOT OIL IN CRACKING SYSTEMS WITHOUT CLOGGING

The Bingham "Koke-Krusher", the only pump that crushes coke, is a field-proven, centrifugal pump specially designed for the severe services of pumping oil products such as *Residuum, Flash Tower Bottoms, Black Oil Recycle*—in which the oil carries in suspension pieces of hard coke of irregular size and shape.

This revolutionary Bingham pump features a coke crushing mechanism located in the suction chamber immediately in front of the impeller eye. Any piece of solid coke entrained in the pumpage *must* pass through the crusher, where it is instantly pulverized, before entering the impeller.

The resulting pulverized coke particles are small enough to assure free flow through the pump and all system equipment. The Bingham "Koke-Krusher" will make a big difference in your operations. Call your nearest Bingham office for full details.

Partial list of Major Oil Companies currently using or installing Bingham Koke-Krusher Pumps:

Canadian Petrofina, Ltd.
Champlin Refining Co.
Cosden Petroleum Corp.
ESSO Standard Oil Co.
Gulf Oil Company
Imperial Oil Co., Ltd.
McCall Frontenac Oil Co.
Shell Oil Company
Sinclair Refining Co.
Socony-Vacuum Oil Co.
Texas Oil Company

Bingham SINCE 1921 — DOUBLE VOLUTE PUMPS — RADIAL BALANCE

BINGHAM PUMP COMPANY

General Offices: **2800 N.W. Front Avenue, Portland 10, Oregon**

Factories: **Portland, Ore. • Vancouver, B.C., Canada**

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NEW ORLEANS, LA.
NEW YORK CITY, N.Y.
PHILADELPHIA, PA.
PITTSBURGH, PA.
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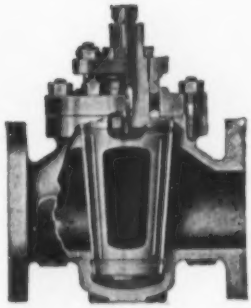
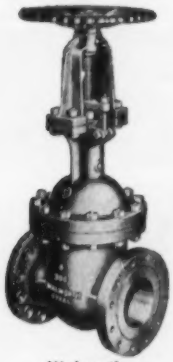
SEATTLE, WASH.
ST. LOUIS, MO.
ST. PAUL, MINN.
TULSA, OKLA.
TORONTO, ONT., CAN.
VANCOUVER, B. C., CAN.

• VALVES
• PIPE FITTINGS



Walworth
Lubricated Plug Valve



Walworth
Steel Gate Valve

Walworth
Iron Body Gate Valve

Walworth
"500 Brinell" Bronze Globe Valve

Walworth
Iron Body Saddle Gate Valve

Walworth
Cast Steel Flanged Fittings

Walworth manufactures a *complete line* of valves and pipe fittings: all made to the highest standards of quality, both as to dimensional accuracy and metallurgical properties. In design, construction, and performance, Walworth products reflect more than a century of experience in the manufacture of quality valves and fittings.

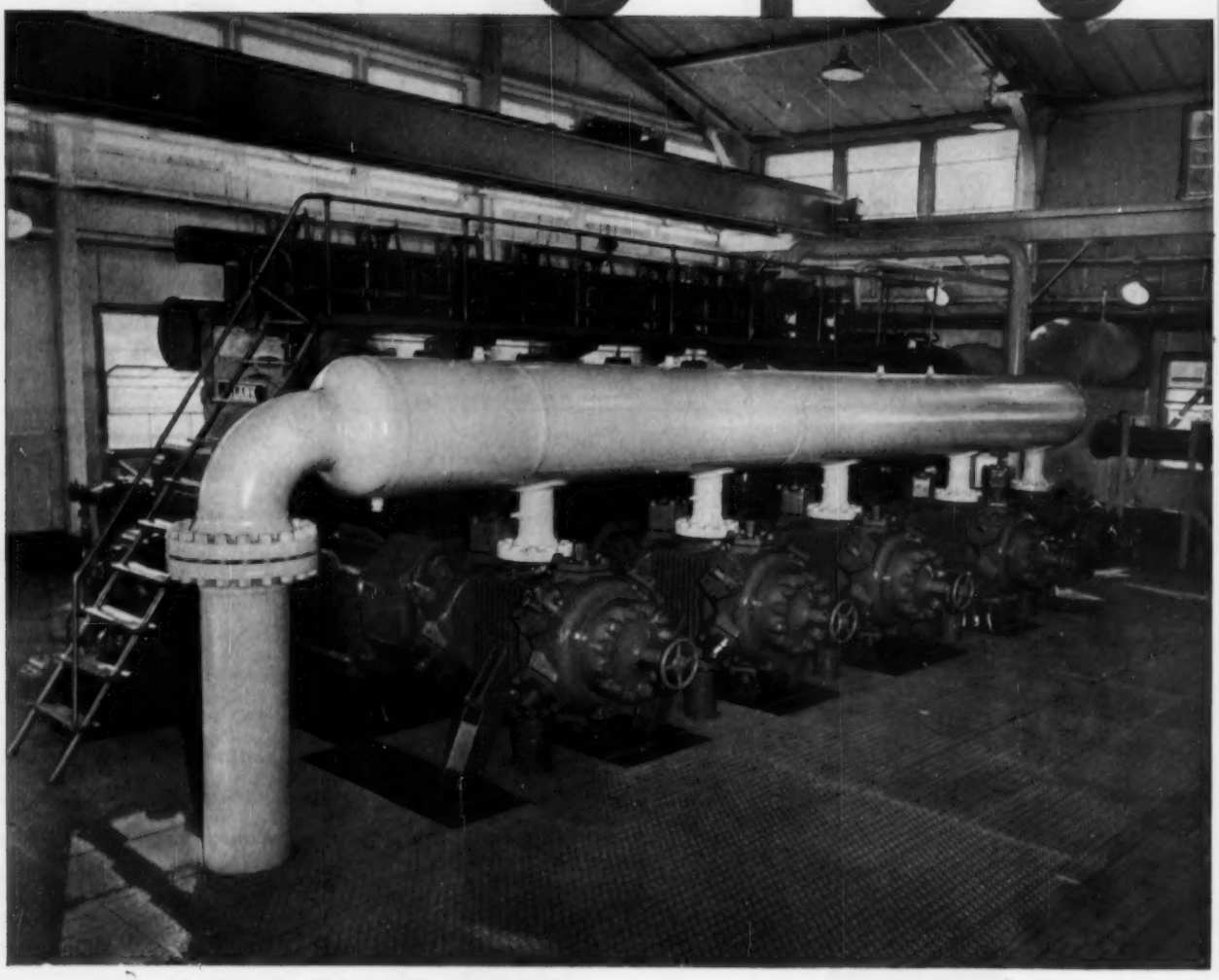
Your Walworth distributor will give you full information on the *complete line* of Walworth steel, iron, and bronze, and special alloy valves and pipe fittings; also Walworth Lubricated Plug Valves, and Walseal* valves, fittings and flanges. Ask for this information today.

*Patented–Reg. U. S. Pat. Off.

WALWORTH
valves and fittings
60 EAST 42nd STREET, NEW YORK 17, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

3400



horsepower

Most Powerful Gas-Engine-Driven Compressor Ever Built*, Delivered by Clark in 4½ Months

Michigan Gas Storage needed a substantial block of compressor horsepower at their Freedom Station in Southern Michigan and they needed it in a hurry. The problem was to build up enough underground gas reserves to meet anticipated heavy winter demands.

They had plenty of station flexibility because of the 12 Clark BA compressors already operating. Therefore, one big unit seemed to be the least costly and the fastest to install. A Clark Turbo-supercharged Model TLA-10 would develop the horsepower required. The efficiency guaranteed by Clark would also mean considerable savings in operating costs.

At the time the need became evident, a Clark TLA-10 had never been built. Nevertheless, Clark promised to build, test and ship this 150 ton unit, including the special turbocharger, in 4½ months or less. The promise was kept and Michigan Gas Storage met their commitments.

For your big jobs, where large amounts of horsepower are required, the big TLA models will really save money before and after installation. For the somewhat smaller installations or those requiring more flexibility, Clark has other Turbo-supercharged models that are equally efficient although less powerful. Eight sizes in the 1100—3400 BHP range are available. Your nearest Clark office will be pleased to furnish you with complete information, or write for bulletin No. 134.

**The TLA-10 operated by Michigan Gas Storage Company is rated at 3300 BHP. Latest models are rated at 3400 BHP.*

CLARK BROS. CO., OLEAN, N. Y.
One of the Dresser Industries
Offices in principal cities throughout the world.

CLARK® — ONE OF THE DRESSER INDUSTRIES®

Turbo-Supercharged Compressors

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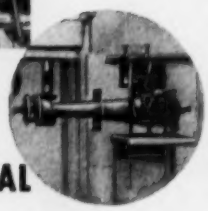
VERTICAL



OR

HORIZONTAL

many more hours on stream without forced shutdown with NATIONAL AIROIL

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Exclusively for vertical firing, the new National Airoil VERTICAL Tandem Block Units retain all the features of our regular horizontal Tandem Units . . . **plus:** special, precast refractory shapes for easier, cost-saving vertical installation and maintenance; secondary air inlet louvres for positive control of vertical flame pattern; and, all steel duplex detaching gear which enables swift, simple vertical burner changeover.

VERTICAL and HORIZONTAL Tandem Units hold air in the combustion zone until fuel and heated air are thoroughly mixed. This means that ignition takes place in a hot zone; the result: high fuel economy through more rapid combustion with a minimum of excess air. NATIONAL AIROIL's patented Tandem Combustion Units allow secondary air to be easily and accurately controlled. By adjusting air control louvres, flame can be shaped to radiate heat uniformly without tube impingement.

The VERTICAL or HORIZONTAL Tandem Unit is always fired with NATIONAL AIROIL Combination Oil and Gas Burners . . . has a high turndown ratio with a steady flame temperature using either fuel oil or gas. With the TANDEM UNIT's clean flame, a cold furnace can be brought to full capacity in a short time.

"Many, many more hours on stream, without shutdown" . . . yes, YOU will realize higher profits from YOUR heaters when NATIONAL AIROIL VERTICAL or HORIZONTAL Tandem Units are specified. Our new Bulletin 498 is yours for the asking.

CHEMICAL-PETROLEUM DIVISION

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The Mail Box . . .

Errata

To The Editor:

In reviewing these articles ("Finding the Properties of Hydrogen Mixtures" by Frank L. Rubin, PETROLEUM REFINER, **35,** No. 3, P. 140 March, 1956), we found several discrepancies of which you may not be aware. In Figure 7 of Mr. Rubin's article, it is evident from consulting the original plot (Bromley, L. A., and C. R. Wilke, Ind. & Eng. Chem., Vol. 43, 1641, 1951) that the parameters .01 through .09 should actually be 0.1 through 0.9. The solution to the first example on page 144 by the Bromley and Wilke method should refer to Figure 7 for ϕ_{12} instead of Figure 4.

Lee Van Horn, Vice President
Process Engineering & Development
The Fluor Corp., Ltd., Los Angeles

The Editor's face is slightly red on this one. The parameters .01 through .09 in Figure 7, page 145 of Mr. Rubin's article should be 0.1 through 0.8 and .009, .09 and .9 in the abscissa should be .008, .08 and .8. The first example on page 144 *should* refer to Figure 7 for ϕ_{12} instead of Figure 4.

Cites Applicability

To the Editor:

The compressibility chart given on page 154 for mixtures of hydrogen and hydrocarbons ("Compressibility Factors of Mixtures" by W. W. Akers and J. D. Burns, March, 1956) might be very helpful to us if we knew the method in which it was derived. Messrs. Akers and Burns do not discuss the derivation of the chart, nor does a quick survey of the literature cited by them reveal with certainty the derivation and limitations of the chart. As it stands, this chart cannot be used by us with any degree of confidence. Further, we require compressibility for lower reduced temperatures than is given.

Lee Van Horn, Vice President
Process Engineering & Development
The Fluor Corp., Ltd.
Los Angeles

Dr. W. W. Akers, Associate professor of Chemical Engineering, The Rice Institute, Houston comments as follows:

Any generalized chart must make some compromise between range of applicability and accuracy. In order to keep a relatively high precision, we have limited the conditions—particularly T_R for the plot. Despite the limitations, the chart permits evaluation of compressibility factors of hydrogen-rich mixtures down to —340 F., certainly within the current industrial temperature range. The chart is not applicable to systems containing appreciable quantities of liquid or solid.

Wants 50 Copies

To the Editor:

In accordance with your announced willingness to furnish reprints of the article "Employing the College Graduate," we should like very much to receive 50 copies, if possible, for distribution to our recruiters in our four divisions and the general office.

R. E. Fry
Office of Employment Supervisor
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Tulsa, Okla.

More Plaudits

To the Editor:

I have just received a copy of your reprint "Employing the College Graduate." This is an excellent article.

May I have, say, 25 copies? I want several members of our faculty to read this article.

O. E. Niffenegger
Office of Placement Service Director
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Presidential Commendation

To the Editor:

If available, I should like to have as many as 12 additional copies of the reprint of the article "Employing the College Graduate." The article represents an important study that I wish to place in the hands of a number of people on our campus.

G. W. Diemer
President
Central Missouri State College
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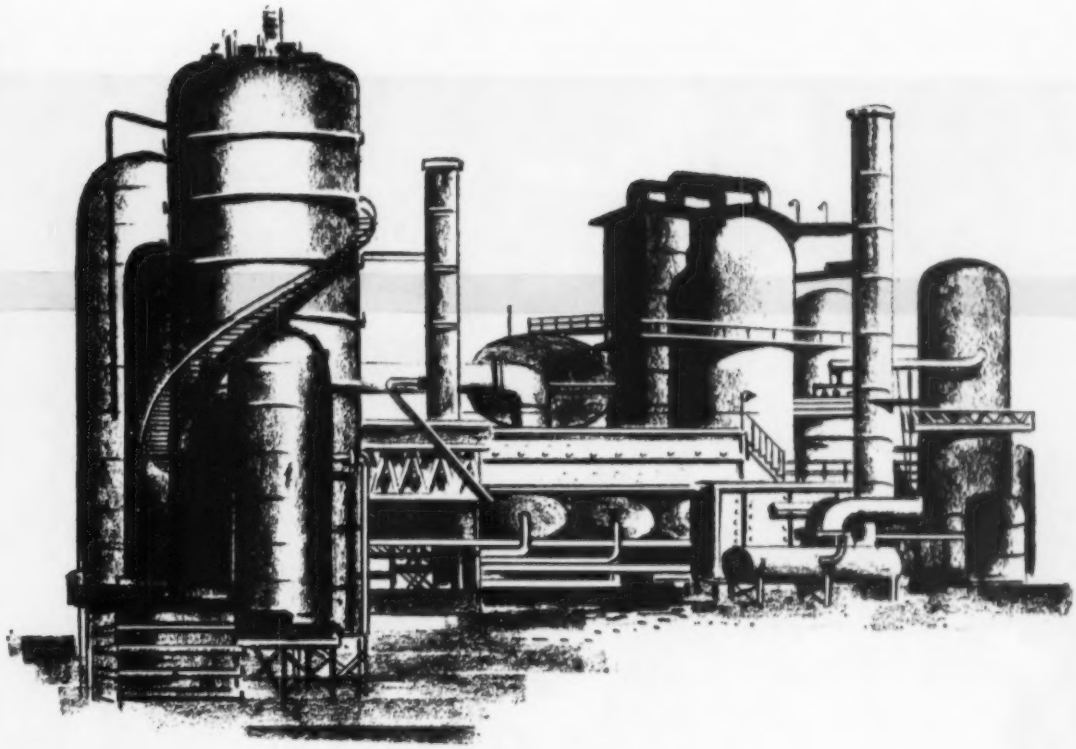

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WHETHER you're developing a new process or modernizing an old one—investigate the unique characteristics of the bearingless *Pottermeter.*

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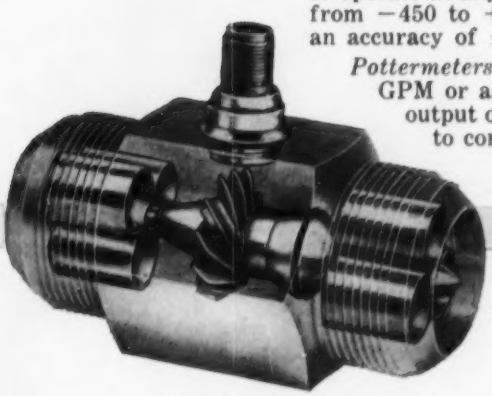

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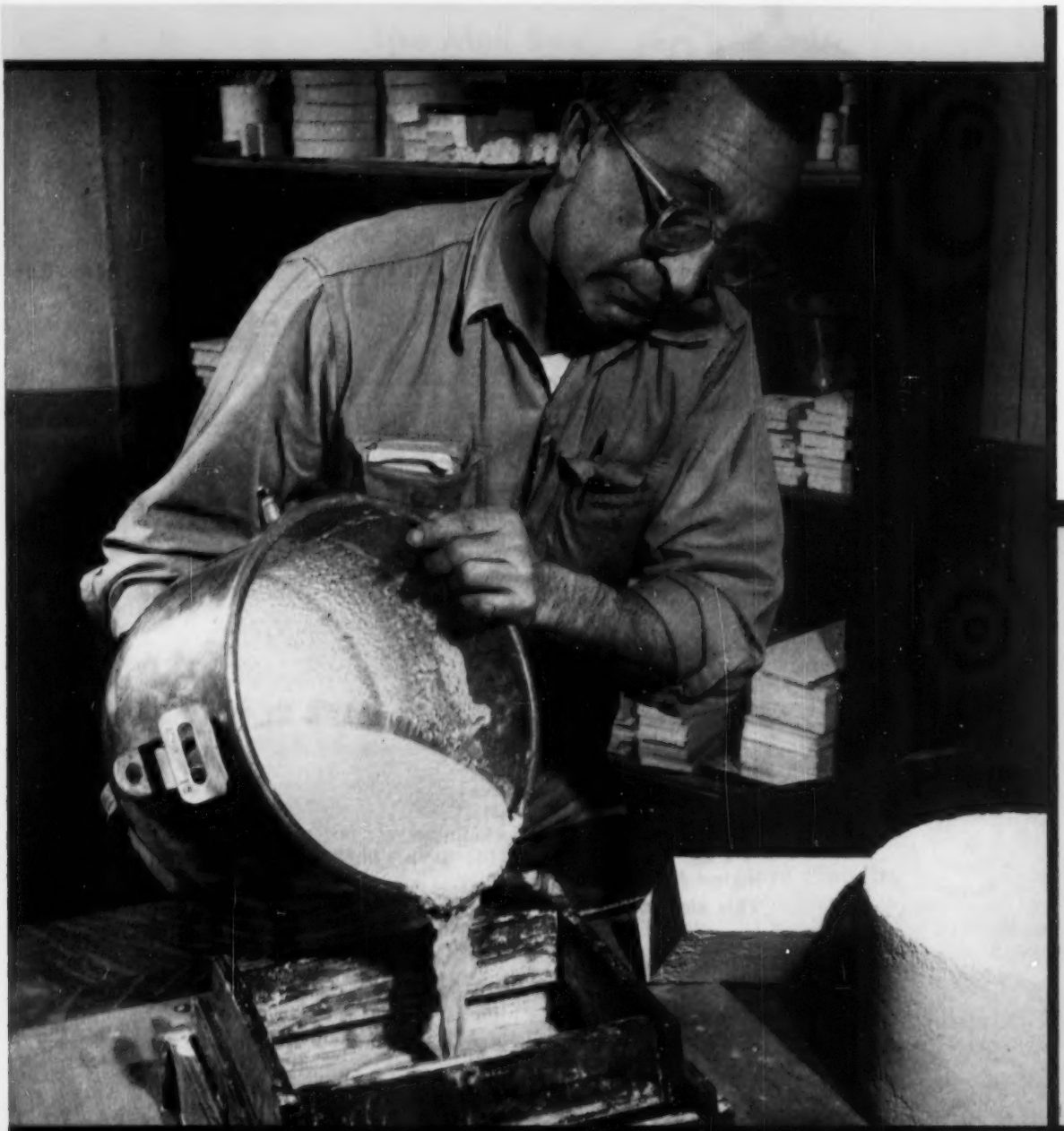

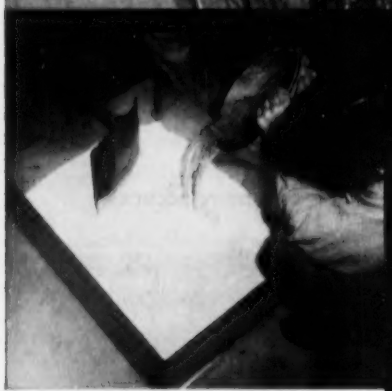

Easy to Mix. Just add water according to instructions. Mixes in about five minutes.

Consistency of Mix is as workable as any cement mix.

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Now you can protect critical areas in your furnaces and other high temperature equipment to 3300°F with ALUNDUM 33-I insulating castable — a new, easy-to-install NORTON Refractory Product.

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- 33-I insulates up to 3300°F.
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Characteristics of ALUNDUM 33-I

Density	100 lbs. per cu. ft.
Setting up time	
Stiffens	1 hr.
Initial set	4 hrs.
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Chemical Analysis — Al_2O_3	Primarily
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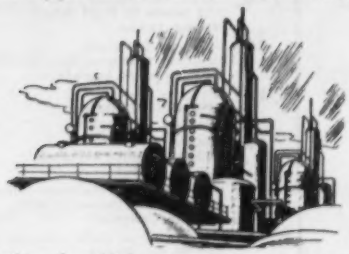
Typical Applications in Chemical Processing



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Here is a simple way to make new friends for your business—and at the same time perform a real service for your industry.

You may ask "does my industry need help?" The answer is *yes*. For today it is urgent that the public appreciate more thoroughly the job oil men do. People must continue to feel the oil industry can best serve *them* by remaining privately managed, fully competitive, and free from excessive governmental control.

You can help in this vital public information program by joining your local Oil Industry Information Committee—made up of oil men from your community. Right now, 33,299 oil men like yourself are active. Aided by the OIIC District Office, your group can provide films, speakers and demonstrations for civic, social and church needs—in addition to classroom materials for high schools.

Joining in this effort will mean real help for your industry. But *you* will also profit. You'll enjoy the great personal pleasure of working with other members of your community. It will mean winning many new friends for yourself—and for your business as well.

So pick *your* number on the map above—and get in touch with the OIIC District Office in your area today! Why not do it *now* while you have the address handy.

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A Quick Look at the Industry THIS MONTH

All Industry Outlook . . .

Flaws in '55-'56 business boom are becoming more pronounced. Even so, future looks bright as ever—consumers continue to set new buying records.

Plus factors: Outlays for plant and equipment expansion to approach $35 billion in '56 compared with $28 billion last year. Incomes at record level. Employment high. Demand for most commodities moving steadily upward.

Minus factors: Auto production and sales are down. Home building slowing up. Farmers' profits falling off. Price of metals up 11 percent over '55. Industry (and farm) debt is mounting—19 percent over last year.

—•—

Refinery Stocks Show Improvement . . .

Refining outlook is promising, as evidenced by lowest residual inventory in recent history. Also, API reports gasoline inventories dropped nearly 5½ million barrels during the first three weeks of April. Result: Refineries are fast getting stocks in shape to meet biggest summer gasoline demand in history.

—•—

Postings on Octane Race . . .

Ethyl reports first drop in premium ratings since June, 1953. April premium octane rating was 96.3—0.1 octane below March. Regular averaged 89.3 for both months. Premium champions are Birmingham, Ala. and Buffalo, N. Y. with 97.5 octane average. Boston and Pittsburgh tied for top regular honors with 91.9.

—•—

Crude Price Hike on the way . . .

Majors—though reluctant at first—are joining independents in big leap on bandwagon to hike crude prices. As experts see it, '56 increase will come *if* refiners hold strong stock position—*if* gasoline demand continues upward—*if* heating oil inventories keep in line—*if*, in this election year, politicians don't kill the increase by grinding it into campaign fodder.

—•—

Steel Prices to Take Another Jump . . .

Pittsburgh Steel Prexy Avery Adams is calling for $12 to $15 a ton increase in steel prices. Other steel leaders are in same mood. Prediction: Biggest steel price jump in history will come after labor settlement this summer.

—•—

Shale Reserves Revised Upward . . .

Four-year study reveals Colorado shale reserves to be twice original estimate. Now 900 billion barrels. New estimate includes only shale deposits expected to yield 15 or more gallons of oil per ton.

Senate has approved $1,200,000 budget to continue oil shale research at Rifle, Colo., and Laramie, Wyo.

—•—

G. E. Tests New Jet Fuels . . .

General Electric announces two powerful new fuels for jet engines. Both are "non-hydrocarbons" and both yield far greater energy than kerosine-based JP 4 jet fuel now used. One is very expensive—would raise unusual problems of engine maintenance and might even require engine re-design. The other, less expensive, would present no engine problems, but would require different shape of plane than today's aircraft.

A Quick Look at the Industry (continued)

Washington at a Glance . . .

Biggest roadbuilding budget in history—$15 billion from taxes—though it passed 388-19 in the House, may find rough going in Senate. House Bill calls for 13-year program totaling $51.5 billion. Senate last year approved 5-year program to cost $18 billion—with no tax provisions.

If Senate approves House proposal, present 2¢ a gallon federal gasoline tax will be upped to 3¢. Taxes also will be hiked on tires, trucks, buses and truck trailers.

Tax depletion allowance will be worn to a frazzle before this election year is out. Recent bill introduced by four Eastern senators to cut depletion from 27½ percent to 15 is expected to find support from "vote-hungry" solons—*unless oil industry does something about it.*

Watch for move to bring more federal interference in oil industry affairs. If recent executive order becomes reality, industrial head of National Petroleum Council will be replaced by government official.

—•—

New Alloy Shows Promise . . .

If *Niphos*—**a new nickel alloy**—lives up to present claims it will do much to conserve scarce nickel supplies. Developed by New York Testing Laboratory, Inc., new alloy is claimed to give iron the corrosion-resistant properties of some stainless steels—and will actually do better job than plating. Inventor says it is cheap and can be applied like paint.

—•—

What's New in Petrochemicals . . .

Amazing growth of plastics industry will continue in '56. Expected production: 4 billion pounds—11 percent over '55. This compares with 3.6 billion pounds produced last year, 28 percent over '54.

Synthetic rubber producers say capacity will jump to 1.7 million long tons a year by late '57—25 percent over '56. Look for synthetic rubber research to move completely out of government hands in near future.

Watch for new developments in chemicals from butadiene apart from its role in rubber industry. Upon completion of present plants, butadiene will be in plentiful supply—will make a logical building block for an industry that may pass up ethylene.

—•—

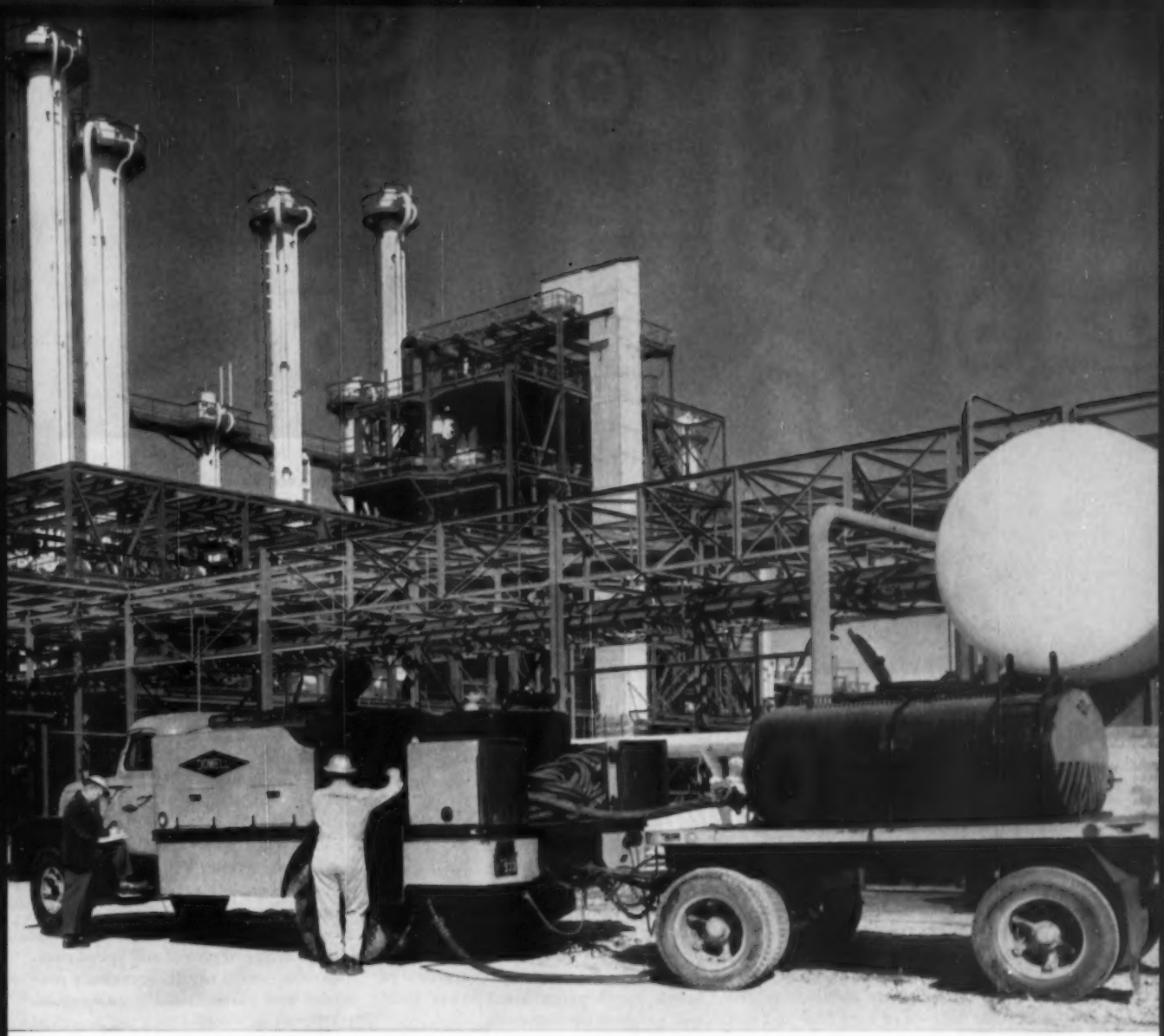
Profits From Electronic "Brains" . .

Electronic computers are profit makers for chemical industry. In making a polymer intermediate, one company fed the operating variables to a computer. Result: Operating conditions were changed to get 25 percent increase in product. The study required 30 hours of machine time compared to 20 years for hand solution by one man.

—•—

New Oil Fields Show Promise . .

Ninety-five new oil fields were ushered in during March. The few showing promise looked a little better initially than most recent discoveries: Cabot Carbon's 1000-barrels per day, 46-gravity, discovery in Lea County, New Mexico; British American's find good for 590 barrels of 39-gravity; Husky Oil's 410-barrel 29-gravity, oiler in Gaines County, West Texas; Amerada's test in McKenzie County, North Dakota, good for 350 barrels of 40-gravity oil; Sun Oil's well making 300 barrels of 32-gravity oil in Terrebonne Parish, Louisiana.



IT'S NOT WORTH THE CHANCE —CLEAN IT RIGHT

Equipment that operates at less than peak efficiency eats into your company profits. Chemical cleaning can help stop these losses—but only when it's done by experts. Unless you rely on experts, you're taking a chance with your men and valuable equipment.

Dowell engineers understand your cleaning problems and they have the *experience* needed to solve them. Thoroughly trained, they're backed by Dowell's 15 years' experience in removing troublesome scale deposits from virtually every kind of equipment in every kind of industry. They're aided, too, by a completely modern, fully staffed and excellently equipped *research* laboratory.

But, expert cleaning goes beyond keeping your equipment in top condition. Dowell considers the safety of company personnel at every step of the operation. The safest possible working procedures are worked out with your safety personnel.

Call Dowell. Our engineers are always ready to discuss chemical cleaning problems with you. There's no obligation. Or write Dowell Incorporated, Tulsa 1, Okla., Dept. E-31.

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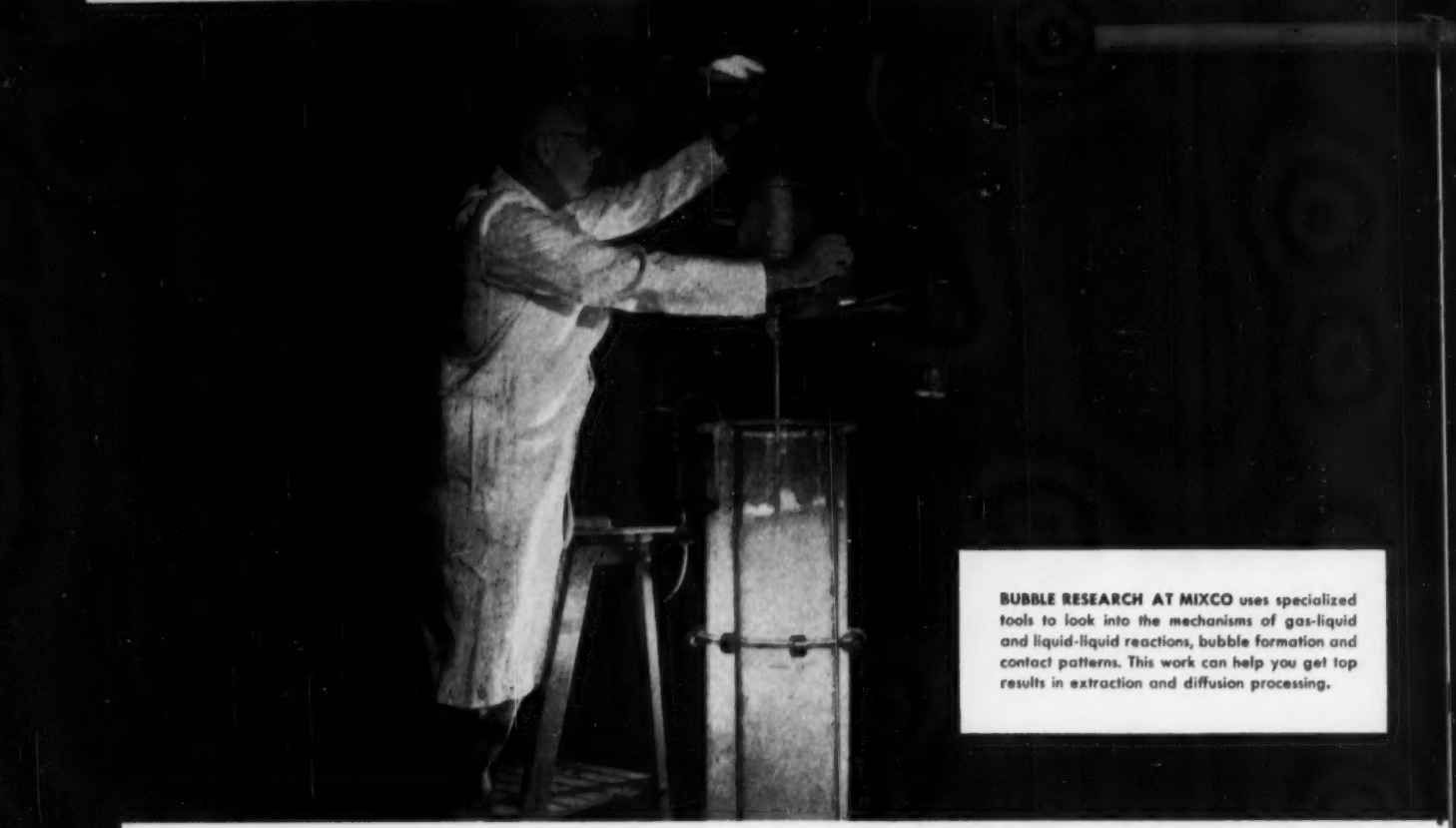

BUBBLE RESEARCH AT MIXCO uses specialized tools to look into the mechanisms of gas-liquid and liquid-liquid reactions, bubble formation and contact patterns. This work can help you get top results in extraction and diffusion processing.

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Do you think good mixing might make a big difference in the way a gas-liquid or liquid-liquid reaction behaves?

We can help you find out, for sure.

You probably want to know whether there's a simple way to discover the just-right balance of fluid flow and turbulence for greatest possible contacting efficiency. (There is.)

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If your work involves gas-liquid contacting, you can save time by letting us figure out for you the most effective sparge ring diameter, and placement of holes, for a given horsepower level and gas flow combination.

On *any* fluid mixing operation, consider the time you'll save by making your pilot runs with calibrated mixing impellers that let you calculate power directly from simple speed measurements. (You can get these impellers from us; or have us do the calculating for you.)

And when you're ready to put the unit on stream, get the advantage of mixer selection from an almost unlimited range of power and speed combinations—with results accurately predicted and *unconditionally guaranteed.*

Doesn't this sound like the *practical* way to put fluid mixing to work for more profitable processing? Thousands of process engineers have found it so. For quick, competent help, phone your LIGHTNIN Mixer representative (listed in Refinery Catalog). Or write us direct.

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Look Out for Atomic Energy

THERE IS NEW OPTIMISM for the future of atomic energy in a peaceful world.

The government "Panel on the Impact of the Peaceful Uses of Atomic Energy" is predicting that there will be enough atomic power plants to furnish 20 percent of all electrical-power generation in 1980. But 1980 is 24 years away.

Let's look at the present energy consumption of the United States, and see where it comes from now. During 1954, petroleum crude furnished 42 percent of the total energy of mineral fuels and waterpower in the United States. Natural gas furnished another 25 percent of the total. Since these percentages have not changed appreciably, this means that our industry is now furnishing 67 percent of the total national energy consumption.

This new form of energy from the atom then may deal our industry a staggering blow once it gets on its feet. It might be a good idea to look closer at this up-and-coming energy source to see what it will do to us.

What Can We Lose? The most optimism for the use of atomic energy is in the generation of electrical power. What are our stakes in this field?

At present, only about 2 percent of the crude petroleum goes to produce electrical power. So even if atomic energy were to take over all of the electrical generating requirements of today, the impact would be little felt by this phase of the industry.

Electric power generation is usually considered a low-profit operation for the manufacturer of refined petroleum products. Constantly, means are being sought to convert these fuels that go to electrical-power generation into higher-profit fuels such as gasoline. We probably will be successful in this conversion by the time atomic energy comes into its own.

Natural gasoline has a little higher stake in electrical generation. About 14 percent of it is used at present for the generation of electrical power. As for natural gas its future is very bright in petrochemicals.

Petrochemicals are just beginning to make an impact on the chemical industry. Even now, about 25 percent of all chemicals are produced directly or indirectly from natural gas. With a future like this, there is little worry for natural gas with the advent of atomic electrical power generation.

What About the Future? Now that the present situation looks brighter, we can relax and take a peek into the future. It is then that we realize the predictions for energy consumption of the United States in 1980 is far more than twice the amount used now. Many of the experts say that even with the improvements we expect in the technology of oil and gas production, we will be only too happy to have atomic energy help us satisfy this staggering energy demand. We can not well afford to neglect the energy demands of our country, since it is our high rate of energy production and utilization that gives the United States the global position it enjoys.

We Can Help It Along—This new form of energy from the atom needs a lot of technological modifications to make it really useful. The cost of nuclear energy construction now is about $300 per kilowatt of capacity while the cost of a conventional steam plant is about $175 per kilowatt. It is easy to see then that the optimism for this form of energy comes from a belief that great technological improvements will be made.

Recently, there have been strong appeals made to the industry to furnish technological and financial assistance to atomic projects. This appeal has been met in part by private industry's pledge to spend $250 million over the next five years for large-scale power reactors.

Our industry stands in a good position to give a helping hand. We keep a large technical staff around to handle the every day problems that arise in our complex industry. We have the engineering and scientific talent required to seek new solutions to knotty situations.

The Atom Is on Our Side—Up to now, we have considered only one phase of atomic energy—electrical power generation. There are other aspects of this form of energy that are getting attention. At least seven oil companies are presently studying the use of atomic energy in processing petroleum products.

Very little is being revealed about the use of atomic energy to replace conventional heat and pressures in refining techniques, but hopes are high. Aside from furnishing process heat, the atomic radiations may supply the energy of activation required to promote certain chemical reactions. This role has been carried in the past largely by catalysts.

We have already learned that atomic radiation will change the properties of some of our products. Atomic radiation will produce a harder polyethylene with greater heat-resistant properties. Standard Oil Com-

Du Pont FOA-2

ashless stabilizer and dispersant for economy diesel fuels

Du Pont FOA-2 can help you make more economy grade diesel fuel from your existing stocks. This is possible because you can use FOA-2 to stabilize your cracked distillates and overcome the incompatibility between blends of cracked and straight-run stocks.

Good filterability

Since Du Pont FOA-2 is an excellent dispersant, it can be used in high temperature operation with excellent results in overcoming filter-plugging and injector-sticking problems. It's economical to use because it is effective in extremely low concentrations.

Ashless

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In heating oils

The ashless feature of FOA-2 also offers advantages in heating oils. Since it leaves no deposits on burner electrodes it does not contribute to ignition failure. For the same reason, it does not interfere with the efficient operation of stack-controlling mechanisms.

Free samples and more detailed information on Du Pont FOA-2 are readily available from any of our sales offices listed below.

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pany of California reports that some synthetic lubricants are better after exposure to atomic radiation.

The use of by-products of atomic radiation have been employed in tracer techniques by our industry long enough that they now occupy a place in our every day thinking. (See: "Take Stock of Radioactivity," by E. G. Fritz in this issue, Page 201.) This technique has given us insight into the mechanism of our industry that would have been almost impossible to obtain by any other means now at our disposal. By using tracer compounds for measuring and gaging, closer control of processes may be achieved.

Radioactive measurements of an area promises to aid us in the discovery of more raw material for our industry—crude oil. Gamma ray and neutron logging of the wells will yield more information about the earth's strata to be used in effective oil production.

The atom promises to serve us in many ways, both inside and outside our particular industry. It reduces the deterioration of foodstuffs. It helps identify and diagnose bodily disorders and then furnishes the treatment for some of these disorders.

In the light of these advancements from the atom, the petroleum industry certainly should have no reluctance in giving all the support it can muster.

A Case of Inequality

A MENACING man-made giant is casting its powerful shadow over American industry. If we allow it to reach maturity without restriction—one crush of its huge fist could mold the world's greatest economy like putty.

Its name is *labor monopoly*. Its creators are a comparative handful of men who united 15,000,000 Americans into a single group through the merger of the AFL and CIO.

Even before these two big labor organizations joined together as one—under one roof—there was anxiety about labor union "giantism." A poll conducted by the Opinion Research Corporation showed the public considerably more concerned about bigness in labor unions than bigness in business.

Despite the feelings of the public, several recent court cases prove that a double standard exists in federal antitrust laws: One under which business monopoly is prohibited—and one under which union monopolistic practices are freed of restraint.

The results of these court decisions are being shoved down the throats of businessmen every day. Labor unions are free to engage in boycotts—to divide territory and exclude business competition—to force employers to deal only with unionized contractors—to dictate what materials and equipment business firms may use—to force work stoppages and plant shutdowns—to drive companies out of business.

The AFL-CIO merger adds even more muscle to these unfair immunities.

Is it fair to cut away at one "giant" with a myriad of restrictions, regulations and laws, and at the same time allow another the freedom of the law to develop its potential all-enveloping power?

The answer lies with those who make the laws of our country. They alone can put new teeth into the Sherman Act. It should and must deal with *all* monopoly power, whether it be manifested in combinations of employers or combinations of unions.

The warning flag is up. If the new giant ever decides to clench its huge fist not only will relations between employers and employes be inside—but our free economy as well.

Symbols of Integrity

THEY SAY a person is judged by the company he keeps. The same is true for a publication.

In the masthead on Page 3 of PETROLEUM REFINER you will notice two highly significant abbreviations—"ABC" and "ABP." We are proud to say these symbols represent the "select" company PETROLEUM REFINER keeps.

The ABC symbol, for example, tells you we are members of the Audit Bureau of Circulation. It tells you our subscription lists are honest—that they are audited and verified semi-annually by unbiased and competent auditors. It also means that all of our subscribers are treated alike. And treated fairly.

The ABP symbol signifies membership in our industry's trade association—the Associated Business Publications; a membership, incidentally, which is partly predicated upon our adherence to the circulation methods and ethics evidenced by our ABC membership.

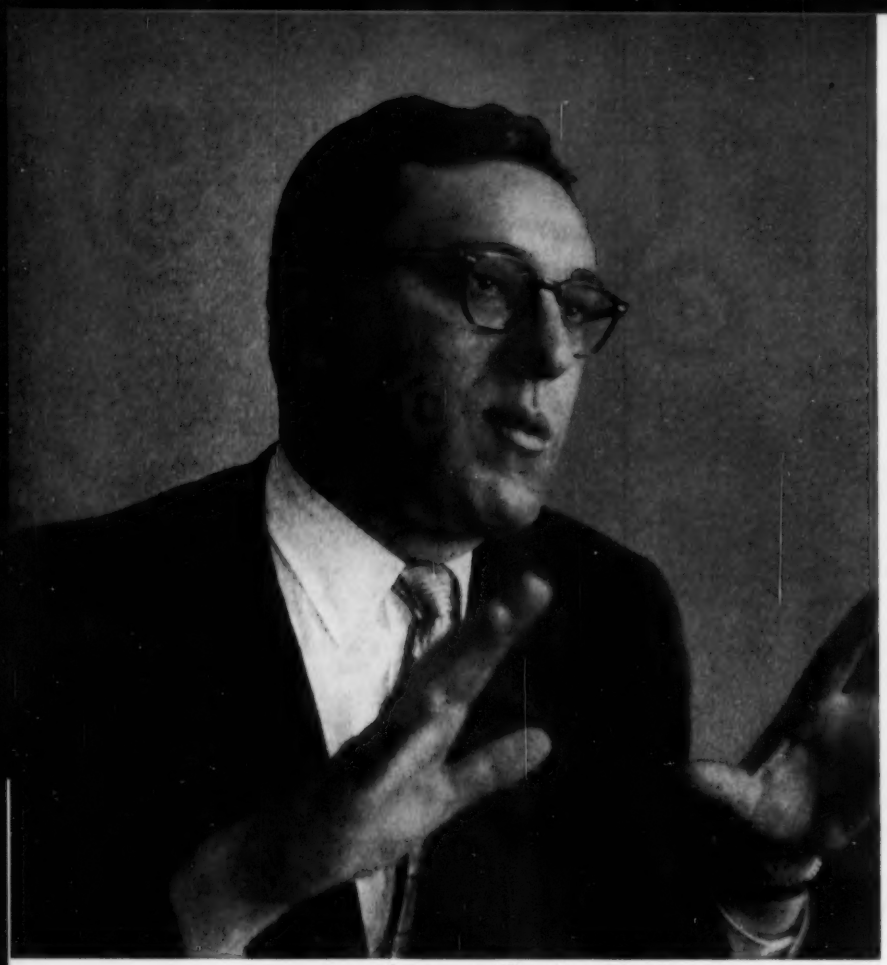
As the Associated Business Publications celebrates its 50th anniversary, we wish to take this space to join the 162 members of ABP in re-pledging our support of the high publishing principles for which it stands. And to re-assure each and every one of our readers that we will continue to observe the first principle in the Association's Code of Ethics . . .

". . . *To consider, first, the interests of the subscriber.*"

Higher Crude Prices Likely

PROSPECTS FOR higher crude oil prices increased sharply during the past month. In the first place, a very strong and concerted demand for higher prices developed from independent producers. This has been widely accepted as necessary to offset increased production costs, but apparently there was reluctance by purchasers to take such action as long as there was a possibility that gasoline supplies might rise to a point of excessiveness.

Now, gasoline inventories have started their seasonal decline without reaching a burdensome level, although they were approaching the point as the turn came. The downward move started early in April after reaching an all-time peak of 198 million barrels on March 30, and by April 20 these supplies had dropped to 193 million barrels. At that level, motor fuel stocks were only 13 million barrels above year-ago supplies and increased consumption is expected to take care of that margin, thereby ending the threat.



. . . many refiners are still trying to catch up . . .

About your top octanes . . .

Refinery Consultant Melvin Gertz answers your questions about the industry's hottest subject

As a service to the refining industry, Ethyl Corporation asked Refinery Process Consultant Melvin Gertz* what can be done to control the increasing cost of top octanes! Here is the interview:

Q. *Are we approaching the end of our present cycle of refinery expansion and modernization?*

A. No. Many refiners are still trying to catch up with the demand for petroleum products. At the same time, two problems have necessitated more building: (1) a leveling out in the market for heavy fuel oil, and (2) octanes have steadily increased.

Q. *How is the industry solving these two problems?*

A. Refiners have accomplished the reduction in fuel-oil yield by installing new cat crackers, increasing coking installations and expanding asphalt production facilities. And fortunately, the addition of cat crackers has also considerably helped in meeting the demand for higher octanes.

However, octane increases have made refiners look to other processes and so that's why we have witnessed a wave of catalytic reforming installations over the past few years.

Q. *What would you say is the major problem that refiners are trying to meet?*

A. Certainly, today, the major emphasis is on filling the need for higher octane fuels.

Q. *Is expansion planning more difficult for the refiner today than, say, ten years ago?*

A. Yes, it is. Although we now have more processes to choose from and our technology for dealing with problems has improved, the industry has reached the octane level where each step requires careful analysis. Moving above the 98 octane level into the 100 plus octane range is expensive, no matter how you do it, and, in some instances, the end products are quite different.

Q. *In your opinion, what processes should a refiner consider in the 98 to 100 plus octane range?*

A. High-severity catalytic reforming, alkylation, isomerization—and combination processes such as catalytic reforming followed by extraction and thermal reforming. All of these processes have their own merits, and in a given refinery each would result in a different combination of gasoline yields and octane ratings.

Q. *Even with the differences in processes, isn't the problem still a matter of finding the cheapest way to produce 100 plus octane gasoline?*

A. No. It just isn't that simple. In some of the newer cars, the engines are relatively mild so that the road octane rating very closely follows the research octane rating. But for many of the new cars, there's some depreciation in road performance below the research rating.

Therefore, in planning octane improvement processes for the future, much consideration must be given to

. . . each step requires careful analysis.

*A partner of Purvin & Gertz, Dallas, Texas.

(Advertisement)

hydrocarbon composition and performance in vehicles as well as to the primary objective of ratings made in the laboratory.

Q. *Are there any other factors in process selection?*

A. Yes. The next factor to be considered is volatility. In some companies there is a definite trend to high volatility gasoline which necessitates removal of many higher-boiling-point top-octane components such as polymer gasoline and heavy cat naphtha from the premium blends. If this trend continues, it will have a significant effect on the selection of future processes. In other words, in addition to merely research octane ratings which have been the primary yardstick for the past few years, economic considerations at this time must be weighed

Moving above the 98 octane level into the 100 plus octane range is expensive . . .

in the light of either present or future importance of such factors as road rating and volatility.

Q. *Don't these various factors depend to a great extent on what automobile manufacturers will be doing for the next ten years in engine design?*

A. That's true and I feel a coordination of effort between the petroleum and automotive industries is of extreme importance at this time. Otherwise, refiners will be hard pressed to make a realistic decision if they are planning to modernize their plant facilities.

Q. *After a refiner has selected his process facilities and built his new plant, are most of his problems behind him?*

A. No, striking the optimum level of operation for all such facilities in a plant becomes a very complex problem. For example, when most catalytic reformers were initially installed, they operated at relatively mild severity, and further octane improvement could be achieved with relatively small incremental losses in yield. Under these conditions the cost of an incremental increase in octane expressed as cents per Research octane number barrel was frequently as cheap in the reformer as it would have been with the use of increased lead. However, with the increased severity demand from cat reformers today, it is generally advantageous to use rather high concentrations of lead.

The optimum combination of severity and lead concentration is . . .

The optimum combination of severity and lead concentration is something that would be peculiar to each refinery, depending on the particular processing facilities and the charge stocks available. Studies of this type should be made with regularity in order to take maximum advantage

Studies . . . should be made with regularity . . . to take maximum advantage . . .

of the facilities available in satisfying your market requirement at any given time.

What Ethyl Research offers you

Our Refinery Technology staff, backed up by the extensive facilities of the Ethyl Laboratories, will be glad to share their experience with your economics people when you conduct a cost analysis of your top octanes.

We will work with you, or if you prefer, we're even equipped to do a complete cost analysis for you.

We can help you answer these and other questions: When should you use "Ethyl" antiknock compound in preference to increasing the catalytic reformer charge rate? How does increased severity of reforming affect your costs? When should you carry your tetraethyllead content to the maximum allowable—and under what circumstances?

For the answers to these and other questions, send for your copy of our new publication "Common Cents per Research Octane Number Barrel." Address your request to Box 14, Ethyl Corporation, 100 Park Ave., New York 17, N. Y.

ETHYL CORPORATION
New York 17, N. Y.

Research Laboratories:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.

'These Get the Job Done for Me'

Did you ever wonder how other supervisors get top results from their employes? Here are 25 leadership secrets . . . direct from those who know.

THE BIGGEST JOB of every supervisor or foreman is to obtain the continued and whole-hearted cooperation of the men and women under his direction. Not so many years ago the supervisor with the best record was the one most accomplished at being an iron taskmaster. That day has disappeared.

In our times it takes many skills, ideas and plans for the modern supervisor to fill the role successfully. He must constantly search for methods of procedure which will assure maximum return from payroll dollars spent by the company in his department.

Getting the job done becomes more complicated, requires added strategy and the use of every possible method developed in business today. Recently 25 successful supervisors were asked about their pet methods of getting maximum results from the men and women under them. Here, in brief form, are their answers.

1. Don't be a watchdog

My job is to get things done through people and I never let myself forget it; every step I take is planned toward that goal. The hardest thing I had to learn was that I was not a ringmaster or watchdog over the people in my department. When this clear understanding of my real role as a supervisor came to me results were better and my work was made a lot easier.

2. Give full credit

The most important one thing that has enabled me to get more done in my particular department is, I am sure, a rule of my own which calls for me always making sure that every man gets full credit for any job well done. I've found that the surest way to discourage initiative and extra effort on the part of the people under you is to overlook such things. Even where we have a bonus for such work I've found the men are just as eager for the recognition of what they have attained as they are for that bonus.

3. Lead, don't force

I try to lead rather than force my people to do the job. Whenever a difficult task comes up I've found it cleared away much faster when I stepped in and took the lead rather than pointed it out and told the men to get the job done themselves. It always results in any given job being performed in far less time than under the old method.

4. Never hurt a man's pride

The biggest thing I've learned in being a supervisor is that you have to be constantly on guard to make sure you never hurt any employe's pride. Sure, you can hire the kind of people who have little pride and are never affected by anything you may do BUT they're not the kind of employes who make any supervisor's job easier for him. Pride is a mighty important ingredient in any worthwhile worker—guard it with care and caution.

5. Treat each person as an individual

The one thing I use to keep my department operating smoothly that I think is of most importance is that I keep studying each man and woman to make sure what particular incentives affect that individual the most. I doubt there are any two alike. When I've found the one which gets top results from any individual then I know how to handle that employe. It sometimes takes several weeks to discover what it is but after that there's a lot of smooth sailing.

6. Explain everything

One thing I've found mighty important is to explain everything. Just telling a man to do something or taking it for granted that he understands all about the problem causes a lot of extra make-up work afterwards and sometimes costly slow downs.

7. Set the example

I set the example I want them to follow. No department in any company is any better than the example set by the supervisor. If he takes a sloppy attitude toward the job his men can't help but follow suit. If he sets an example of initiative, love of his work, interest in every job, etc.—his men will always follow suit.

8. Weigh what you say

I've found the most important single thing in getting the job done is to be extra careful of what you say and how you say it. When you do that your words will mean something to the people toward whom they are directed. By doing this you also cut down possibilities for misunderstandings and mistakes.

9. Promote friendly competition

My chief policy is to promote a competitive spirit among the men in my department. Competition always makes for better results even if for nothing

more than to see who can keep his work the cleanest, turn out the least number of errors, or some other element strictly between the men themselves. One word of caution—make sure that's not belligerent competition.

10. Be a good listener

To me it's most important that a supervisor learn to be a good listener rather than completely dominate every conversation he has on the job with the men under him. When you are a good listener you draw your men out—get them to thinking more about the work, developing their own ideas and taking a greater personal interest in the job.

11. Don't play favorites

To me the big thing in getting the job done is in keeping a smooth running operation. I've found one sure way to assure that, is to bend over backwards to avoid playing favorites. Then everyone on the staff works better with the other fellow on the job.

12. Stop trouble before it starts

I try to locate troubles before they break out. Just about 25 percent of my time is spent doing this. Experience has taught me it's a lot easier to patch up something before it comes to the surface than to clean up after it has boiled over.

13. Don't gripe

I always keep a favorable attitude toward the company. What gripes I have against the front office I keep to myself. I've noticed that where supervisors air their dislikes in front of their men the efficiency drops right there and soon the whole group is doing the same thing.

14. Learn patience

Patience is the greatest asset any supervisor can have in handling any man or any problem. Until he learns patience he can't call himself a good foreman. With it you never make snap judgments.

15. Be fair

The toughest job any supervisor ever faces is in disciplining one of the employes under him. It's a point at which he can start a chain reaction which will lead to an explosion of future trouble for him. I make sure I have all of the facts before I ever discipline any employe. That's kept me from making mistakes which could have disrupted my whole department later on.

16. Praise good work

My pet method of getting the job done is to find every opportunity I can to praise individual employes for their work. It accomplishes wonders. But it can be dangerous if overdone; you have to learn the proper balance and adhere to it.

17. Avoid prejudice

I'm careful to avoid prejudice against any individual employe. If he has feelings, traits or actions I dislike I ignore them completely as long as that individual does a good job. I've seen too many cases where supervisors let prejudices against certain employes ruin all of the other good things they have done and completely mess up their departments.

18. Build the man's job

To me one of the most important things you can do is to never overlook an opportunity to build up a man's job in his own estimation. The man who is proud of his job always does more for you with less trouble.

19. Accentuate the future

I keep building on each employe's future with the company. I've found the men under me have to have goals toward which to work hard; without them they never have the incentive to do anything extra. I never overlook an opportunity to do this.

20. Avoid destructive criticism

A supervisor has to dish out criticism; that's one of the reasons he's in his job. But I've found there are two ways to do it, i.e., constructively or destructively. The former gets the best results. Whenever I criticise my employes it's done constructively . . . and I've always had good results with this approach.

21. Show appreciation

Show an interest in and appreciation of his work; that makes him a better man and easier to handle. Confine your efforts to keeping him working and he'll use every dodge he can think of to keep from doing anything extra.

22. Discuss job problems

My pet rule is to always discuss every job problem with the men involved. Following it has done more for me in my department than anything else I've ever tried to do. You get more willingness to do something extra from your men when they have a chance to help you work things out.

23. Stress individual initiative

One of my pet methods of getting the job done in my department is to give my men things to work up on their own. That keeps them from being mere machines. It keeps them alert. It enables them to have that something extra when they have to think out a problem all by themselves during an emergency.

24. Don't make false promises

I carefully avoid making promises that I may not be able to fulfill. I've found that's a bigger source of resentment by employes against their supervisors than anything else. When it involves the company I make sure first it will be delivered before I promise my men anything.

25. Be consistent

I try to be consistent in my approach to all of the problems concerned with my department. I've found the men are then never afraid of my moods or uncertain about what I will do. It also helps them work out a lot of problems on their own. # #

Turn to Page 268 for other As-Management-Sees-It articles.

Computer Session

Computers Take Over

The evolution of computers in this refinery led the group to order one of the latest model, large-scale, high-speed computers. Here are their recommendations.

Robert G. Donovan and Robert W. Schrage
Esso Standard Oil Company, Linden, New Jersey

Computers have become an important factor in the petroleum-refining industry. Their most important use is in economic planning of refinery operations. Here are some suggestions for getting computer activities started within a refinery:

1. Select a nucleus group of one or two people with the initiation of a computing activity as their full-time assignment. This group should comprise chemical or petroleum engineers who have had at least a few years of refinery technical experience. It has been generally found that this work requires people who possess an inquiring mind with good analytical ability and an aptitude for dealing in abstractions. Selection of candidates should be on that basis.

2. The initial project should not be a trivial one, but some application important enough to firmly establish the computing activity. A minimum time investment of six months would not be unreasonable for an initial project.

3. Long-range equipment commitments can be avoided by renting computers full time or on an hourly basis (most manufacturers and some independent service organizations maintain installations available for such "spot" use on a contract basis).

4. If the results of early efforts are favorable, the refiner may consider continuing a rental agreement, or he may decide to purchase equipment outright. Factors such as cost, obsolescence, and maintenance must be considered in this case.

5. If a group is established to carry out operations research, it should be in close contact with the computing activity. These fields, although distinct, tend to complement each other.

6. Expansion of the computer group in later years may be achieved from within, or by direct hiring of computer-trained people. However, it seems desirable to have a majority of the group experienced in petroleum processing.

7. The decision concerning where in an organization this activity should be situated should take into account the research character of work in this field. To the extent possible, this activity should be (in an organizational sense) somewhat removed from day-to-day operating pressures.

Condensed from the presentation made before the API Refining Division, Montreal, May 15, 1956.

How Computers Evolved In One Refinery

1. *An electro-mechanical calculator* representative of early, simple punched-card equipment was used to determine the value of virgin and intermediate refinery streams. Took 20 minutes of machine time instead of the 3 hours of hand calculations.

2. *A card programmed electronic* calculator with greater memory capacity and speed was added. Trial and error calculations made of the yield and quality of products from most of the processes within the refinery.

3. A computer with stored program was tried. A 24-hour hand calculator, that takes 2 hours on the CPC, requires only 2 minutes on stored program computer.

4. Plans to purchase larger computer for its ability to handle both accounting problems and engineering calculations with ease. Delivery is not expected until late 1956.

Computer Session

Use Computers For Refining Problems

A high-speed electronic computer establishes optimum operating conditions which are impractical to determine with a desk calculator.

Jack Sherman
The Texas Company, Houston

IN ORDER to make petroleum products conforming to given specifications, various unit processes are used in a modern refinery. There generally exists some freedom in determining the compositions of the various products and in choosing values of the controllable process variables. Moreover, the product specifications, crude-oil supply, and refinery operations do not remain constant for long.

All of these factors must be considered to determine the optimum operating schedule for a given situation. Usually a detailed material balance for the entire refinery is required. The associated numerical computations then are voluminous so that it becomes impractical to consider more than a small number of cases by means of desk calculators.

This type of computation has been performed recently in The Texas Company on a large-scale electronic digital computer. The digital computer provides the flexibility needed to handle the trial-and-error type of computation which is characteristic of refinery process studies. This puts the company in a much better position to meet unexpected situations. It also frees the process engineer from tedious desk computations and enables him to be more productive.

The general-purpose machines commercially available at present range from small manually-operated desk calculators to large electronic systems capable of performing thousands of numerical operations per second. These electronic computers have other essential characteristics in addition to high speed. One is their ability to make logical decisions, such as an alteration of the sequence of arithmetic steps at some intermediate stage of the problem, dependent upon some intermediate result. Another characteristic is the storage within the machine of all the data and arithmetic instructions at the outset, with subsequent high-speed random access to any item of data or to any instruction.

The optimum values of controllable process variables, which will result in producing the finished products in the desired amounts and with given specifications, may be determined after a large number of calculations. Under certain conditions, it may turn out that no combination of process variables exists which will be satisfactory.

Thus, if a refinery is operating so as to produce motor gasoline and other products and it is desired to increase the octane-number specifications of the gasoline by a small amount, it may be possible to do so by changing the schedule of operations. However, as the desired octane-number increase becomes larger and larger, there will be some point at which the refinery will be unable to meet the desired specifications with the equipment at hand. In this case, it will be necessary to introduce an additional process such as catalytic reforming.

Consider a refinery operating with given crude avails and producing gasoline and other finished products conforming to given specifications. In general, the specifications determine neither the compositions of the products nor the values of the process variables uniquely. The specifications are frequently maximum or minimum specifications rather than unique values. At the outset the parameters in the refinery system are the values of the process variables, such as feed rates to the various units, operating temperatures, etc., and the compositions of various intermediate streams and of the finished products.

From the mathematical standpoint one has a set of simultaneous inequalities involving the process variables and compositions, in terms of the specifications of the finished products. Computationally, it is desired to determine the permissible ranges of the parameters which satisfy the set of simultaneous inequalities.

When these computations are carried out by a refinery engineer by means of a desk calculator, a complete mathematical formulation of the problem is omitted. The engineer frequently makes "decisions" during the course of the computations, based upon past experience, in order to arrive at a satisfactory set of process variables and product compositions within a reasonable period of time. However, it is rarely practical, when a desk calculator is used, to explore the complete permissible range of parameters so that a given set of values can be determined within this range which optimizes profit or achieves some other desired condition. Thus the need has been felt for utilizing a high-speed electronic computer having the necessary flexibility and capacity to handle the complete problem.

The Texas Company decided to carry out some refinery processing studies about two years ago by means of a large electronic computer. It was available at that time on an hourly rental basis.

The company's Eagle Point Works, at Westville, N. J., was chosen as the refinery for this study because of its intermediate size and its proximity to New York City where the computer was located. The specific problem involved an evaluation of several possible crude oils in order to provide a basis for decision as to what crudes

should be made available to this refinery for future processing.

The first problem was that of obtaining a complete mathematical simulation of the Eagle Point Works. This involved converting the numerous graphical correlations to equation form. These correlations are of two general types, one of which relates the pertinent properties (API gravity, 50-percent point, viscosity, etc.) of the effluent streams in a given unit process to the properties of the feed and operating variables of the process. The second type of correlation involves the blending of primary and intermediate streams and the relationships between the properties of a blend and those of the components. In both cases these correlations are based upon plant and laboratory data and are specific to each refinery.

In some cases it turns out to be quite difficult to obtain an equation which agrees with a graphical correlation sufficiently well over the complete ranges of the variables. However, in these cases it is usually satisfactory to approximate the entire curve by two or more straight-line segments over smaller intervals, since the electronic computer can be programmed to select the proper interval for a given value of the independent variable and then select the corresponding linear equation with which to compute the dependent variable.

The next problem, after a suitable mathematical model of the refinery had been obtained, was to perform the numerical and mathematical analyses of the system. When the equations are nonlinear, as was true in the case in question, no general mathematical method is known for the direct solution of a system of simultaneous equations and inequalities. Trial-and-error procedures are required, and these must be formulated in complete detail. This was followed by a detailed description of the flow of the computations leading to the desired results. The flow involves all the decisions as to the exact sequence in which the computations are to be carried out, the information to be printed, and the like.

The next step is to translate the computational flow into a series of instructions which can be introduced into the machine and carried out at electronic speed. This coding invariably contains errors and so must be checked and corrected in so far as possible before real production can begin. In a complex problem where many alternative paths of computation can occur during the course of the problem, it can become entirely impractical to verify the correctness of every possible flow at the outset. In a case of this kind, the only practical procedure is to start using the program and to eliminate errors as they are discovered in use. When the program has been in use on a large variety of problems, the reliability increases and approaches certainty.

The time required, in this instance, to set up the mathematical model, perform the numerical analysis, and code and check out the computational machine program was approximately eight man-months. Thereafter, a complete material balance under a given set of conditions could be obtained in approximately 15 minutes, as compared with a week or more for the hand calculation.

This difference in time has several important consequences. It liberates the process engineer from tedious desk computations, and so enables him to be more productive, with consequent increase in interest and morale. Moreover, with the present critical shortage of technically trained people available to industry, the use of a high-speed computer is one of the few ways available to a company to increase effectively its technical productivity with its present technical staff.

Another important advantage of using a high-speed computer for processing studies is that it puts the refinery in a much better position to meet unexpected situations where quick action is required, e.g., in the breakdown of a piece of equipment or the sudden necessity to use a different source of crude oil.

The first set of material balances obtained for the Eagle Point Works of The Texas Company seemed to be at variance with what the process engineer expected intuitively. However, a detailed study of the results showed them to be correct, and that intuition was not reliable in qualitatively predicting the effect of numerous variables changing simultaneously. The results suggested a new series of balances to be computed, the results of which proved to be informative.

Thus, by alternately computing and studying the results, the engineer was able to increase his knowledge of the operating characteristics of the refinery in a matter of days—information which could not have been obtained in several months of hand computation. This is perhaps the most important consequence of electronic machine computing.

Even more broadly, it becomes practical for a company such as The Texas Company, which operates several refineries, to consider its simultaneous operation with respect to optimum crude-oil allocation and optimum overall operation. The computations can be extended to include considerations of distribution costs of crude oils and finished products, of production costs of crude oils, of statistical analysis of sales to forecast demand, and the like.

There is no doubt that the ultimate result of using high-speed electronic computers to attack this general problem will be to achieve a significant increase in refinery operating efficiency.

Original presentation at API Division of Refining, Meeting, Montreal, May 15, 1956.

Meet the Author

JACK SHERMAN has been with The Texas Company 15 years. At present he is in Houston, working on the use of large-scale digital computers in solving refinery problems. Dr. Sherman is a graduate of the University of California at Berkeley and took his Ph.D. in chemistry at California Institute of Technology. He is author of a number of articles in physical chemistry, statistics, computational methods and the use of computers in petroleum problems.

Computer Session

Equilibrium for C_6's and Hydrogen

The results of this computer work will be very useful for processes such as reforming, isomerization and dehydrogenation.

E. B. Weinberger and C. W. Montgomery
Gulf Research and Development Company, Pittsburgh, Penn.

THE PURPOSE of this paper is to illustrate the use of computer techniques to determine the equilibrium compositions comprising all principal C_6 hydrocarbons at selected temperatures, pressures, and hydrogen-hydrocarbon ratios. While the primary purpose is illustrative, the system chosen for study is not entirely without practical significance in view of current interest in reforming processes. Furthermore, the dehydrogenation and isomerization equilibria involved in the calculations are known to be established over conventional metal and metallic-oxide catalysts.

The mathematical analysis of the equilibrium system was accomplished by a variation of the method proposed by Brinkley.[1] He showed that it is always possible to choose *independent* components, so that the remaining *dependent* components can be expressed in terms of properly written chemical equations involving only some or all of the independent ones.

In this case, we find it expedient to choose hydrogen and *n*hexane as the independent components. We may then write the following equation for any other C_6 hydrocarbon:

$$\mathrm{n-C_6H_{14} \rightleftarrows C_6H_{14-2s} + sH_2}, \qquad (1)$$

where $s = 0, 1, 2, 3,$ or 4.

If we let $n =$ moles of hydrogen, and $n_x =$ moles of *n*hexane present at equilibrium, the equation for the theoretical number of moles of any other C_6 component present at equilibrium may be written as follows:

$$n_s = \frac{K_s N^s n_x}{(Pn)^s}, \qquad (2)$$

where K_s is the equilibrium constant for equations (1) for a particular hydrocarbon of the class C_6H_{14-2s}, N is the total number of moles in the system at equilibrium, and P is the total pressure.

The three simultaneous equations for this system involve the three variables n, n_x, and N, and may be written:

$$\left.\begin{aligned} q - n + n_b + 2n_c + 3n_d + 4n_e &= 0 \\ q_x - n_x - n_a - n_b - n_c - n_d - n_e &= 0 \\ N - n - q_x &= 0, \end{aligned}\right\} \qquad (3)$$

where n_a, n_b, n_c, n_d, and n_e are the total number of moles at equilibrium in each of the respective classes: C_6H_{14} (not including *n*hexane), C_6H_{12}, C_6H_{10}, C_6H_8, and C_6H_6. These can, in turn, be represented in terms of the basic variables, n, n_x, and N, by means of equation (2). The quantities q and q_x are the "effective" moles (so called by Brinkley) of hydrogen and *n*hexane which would result if all the dependent components were transformed into independent ones by reversing equation (1). This is done for the purpose of facilitating the mass-balance equations.

The quantities q and q_x may now be obtained from consideration of the amount of hydrogen (H) and carbon (C) in the feed. In this situation we have:

$$\left.\begin{aligned} Q &= 2q + 14q_x \\ Q_x &= 6q_x \end{aligned}\right\} \qquad (4)$$

where Q and Q_x are the mole atoms of H and C, respectively, in the feed. However, in this particular instance, the feed happens to coincide with the independent components, so that we may set q and q_x directly. As a counterexample, the feed might have consisted entirely of cyclohexane, say, with the independent components as above. In this study, we choose $q_x = 1$ and $q = r$, where r varies from 0 to 1 in 0.1 increments. Thus, $N = 1 + n$.

The variation of Brinkley's method which we have applied in similar systems[2] is due to the observation that a more efficient computation results from the elimination of n_x between the first two of equations (3) to yield a single algebraic equation in n of no higher degree than before.

The resulting equation has the following form:

$$f(n) = An^5 - Cn^3 - En^2 - Gn - I - r(An^4 + Dn^3 + Fn^2 + Hn + J) = 0$$

Where:

$A = 1 + a + b + c + d + e$	$D = b + 2c + 3d + 4e$
$C = b + 3c + 6d + 10e$	$F = c + 3d + 6e$
$E = 2c + 8d + 20e$	$H = d + 4e$
$G = 3d + 15e$	$J = e$
$I = 4e$	

(5)

When equation (5) is solved for n, we may easily find n_x from the following:

$$n_x = \frac{n^4}{An^4 + Dn^3 + Fn^2 + Hn + J} \qquad (6)$$

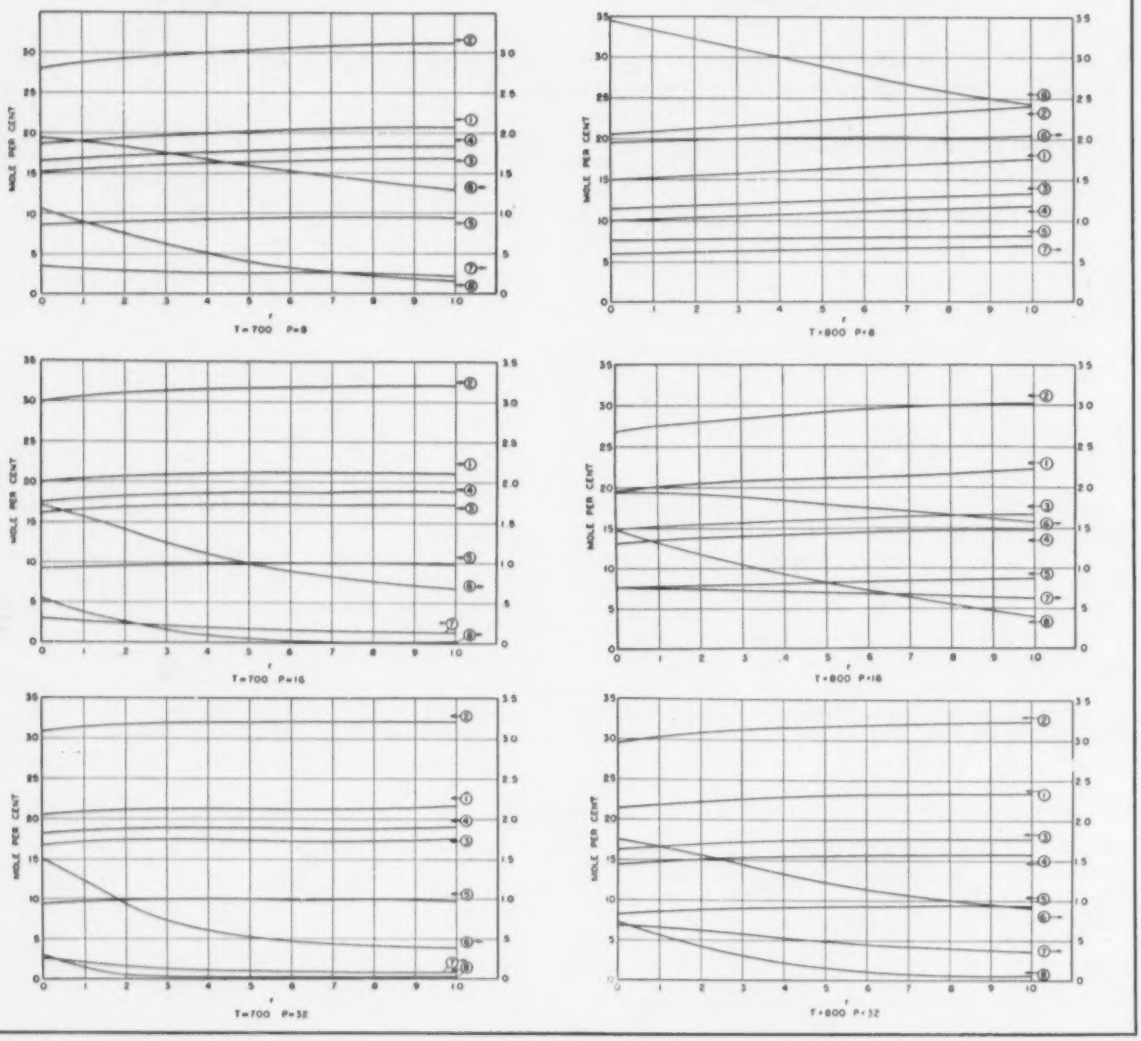
Then, since $N = 1 + n$, we can solve for the number of moles of each of the other components (or groups of components) from equation (2).

In this study, some grouping of components was used so that only the total hexenes, hexadienes, unsaturated naphthenes (C_6H_{10}), etc., were found. Solution of individual compounds was restricted to hydrogen, each of the hexanes, cyclohexane, methylcyclopentane, and benzene. Equilibrium calculations were performed for 99 sets of conditions with the use of temperatures of 700 F, 800 F, and 900 F; pressures of 8 atm, 16 atm, and 32 atm; and $r = \frac{\text{hydrogen}}{n\text{hexane}}$ ratio in the feed from 0 to 1 in 0.1 increments.

Equilibrium constants for all the major components

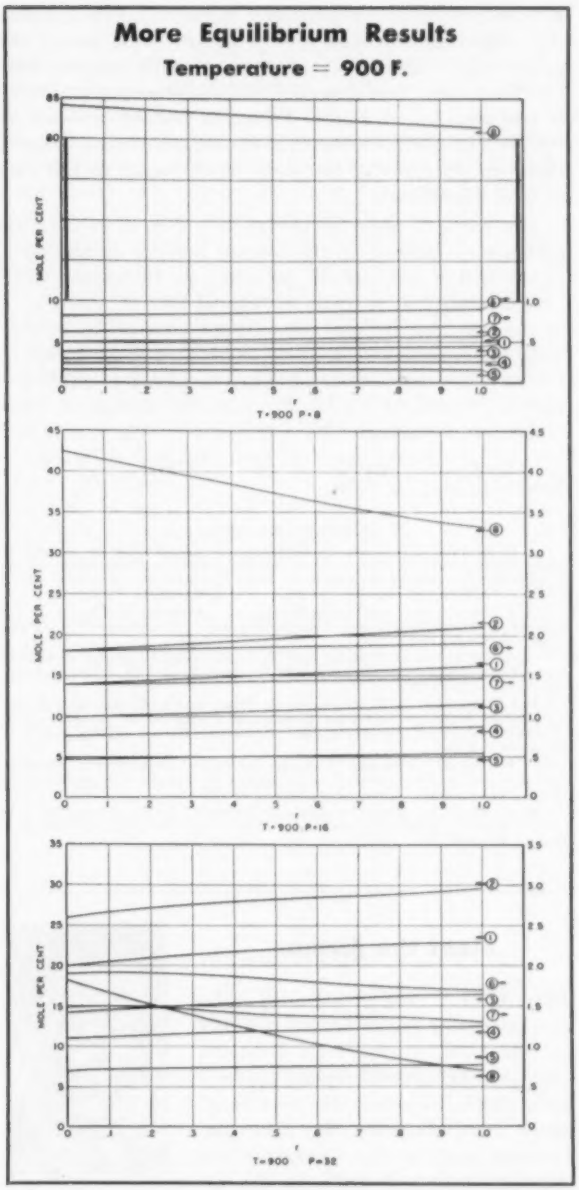
Here are the Equilibrium Compositions which were determined by the digital computer.

Temperature = 700 F. **Temperature = 800 F.**



were obtained by interpolation in the tables of free-energy data published in connection with API Research Project 44.[3] However, many of the minor components are not listed in these tables. For this reason it was necessary to obtain at least a reasonable estimate of the free energies of formation in order to determine which should be included in the calculations. For the most part, the superposition method of Rossini, Pitzer, and their associates[4] was used. The group contribution method of van Krevelen and Chermin[5] was also used for those compounds not easily estimated by the first method (such as certain ring compounds) and to check the results from the first method. Since all of the components so estimated were expected to contribute very little, certain secondary contributions to the free energy, such as alteration of restricted rotation by substitution of ring formation, were neglected.

From these estimates it was possible to ignore certain classes of compounds entirely in the equilibrium calculations. These included the following: all acetylene compounds, all trienes, nonconjugated dienes, and compounds with cyclopropane rings or with more than one ring. Certain other classes were thought to be on the border line and were included: viz., unsaturated cyclics (C_6H_{10}), conjugated hexadienes, substituted cyclobutanes, and conjugated unsaturated cyclics (C_6H_8). It was found that the first three of the above classes made maximum contributions of 0.04, 0.01, and 0.03 percent, while the last class was presumably less than 0.005 percent because the calculations were rounded off at hundredths of a mole



percent. The equilibrium constants used for each of the compounds included in the calculations are listed in Table 1.

The digital computer used for these calculations was the CRC 102-A, manufactured by the Computer Research Corporation, now the National Cash Register Company, Electronics Division. We have made extensive modifications of the basic computer in order to facilitate certain input and output functions. A fairly complete description of both the basic equipment and our modifications have been published previously.[6]

The calculations may be described as follows:

1. Feed to the computer the equilibrium constants for the individual as well as grouped components with the scale factors previously noted.
2. Use the grouped constants to calculate the coefficients of $f(n)$ as well as $f'(n)$.
3. Generate a starting value for n_0, when $r = 0$.
4. Use the last approximation to n to calculate $\frac{f(n_k)}{f'(n_k)}$.
5. Test to see whether the quantity obtained in step 4 is significant. If it is not, the correct value of n has been obtained, and the program proceeds to step 7. If it is significant, the calculation has not converged, and the program proceeds to step 6.
6. Obtain a new trial value of n by subtracting $\frac{f(n_k)}{f'(n_k)}$ from the old value of n, and the program returns to step 4.
7. With the correct value of n, calculate n_x and N.
8. Calculate the values for the dependent components, and print the results for this case.
9. Add 0.1 to r for the next case, and add 0.1 to the last value of n to serve as an approximate starting value for the next set.
10. Test to see if $r > 1$, i.e., if all the cases for this temperature and pressure are complete. If not, return to step 4; if so, go to step 11.
11. Double the pressure, and reset the quantity r to 0.
12. Test to see if $P > 32$. If so, the entire pressure range has been completed for this temperature, so go to step 14. If not, go to step 13.
13. Adjust the quantities $\frac{K_x}{P^x}$ for the pressure change. Go to step 2.
14. Reset P to 8, set T (temperature) to the next temperature.
15. Test to see if $T > 900$ F. If so, go to step 16; otherwise, go back to step 1.
16. Halt.

It can be seen that the program can be easily rerun, if more precise equilibrium constants become available, by simply changing the input data. Other conditions of temperature, pressure, and feed can be studied by simple changes in the program and input data. The calculations for each set required 3½ minutes, of which about 2 minutes was required for the rather elaborate output printing.

The results of these calculations are shown in the accompanying graphs where the equilibrium compositions are plotted as functions of r, the hydrogen-hexane mole ratio in the feed. The parameters for these graphs may be identified as follows:

Numbers in illustration signify as follows: (1) *n*hexane; (2) 2-methylpentane; (3) 3-methylpentane; (4) 2,2-dimethylbutane; (5) 2,3-dimethylbutane; (6) total naphthenes; (7) total hexenes; (8) benzene.

It is evident that the equilibrium compositions changes greatly within the range of temperatures and pressures shown here. The system is predominantly isoparaffinic at 700 F and 32 atm and is predominantly aromatic at 900 F and 8 atm. On the other hand, there is relatively little variation in the concentrations of total hexenes and total naphthenes over this range.

What variation does occur is of interest, however, because in certain cases the effects produced by changes in operating variables are contrary to preconceived ideas. This is illustrated in Table 3, where the total hexenes and total naphthenes are tabulated for the nine temperature-pressure conditions at the extreme values of the hydrogen-hydrocarbon feed ratio, $r = 0$ and $r = 1.0$.

Inspection of Table 2 reveals several interesting points. Ordinarily one would assume that the equilibrium hexene

API Computer Session

concentration would increase with increasing temperature. Although this is true at the two higher pressures, 16 atm and 32 atm, it is not the case at 8 atm, where the hexene concentration exhibits a maximum with increasing temperature at both $r = 0$ and $r = 1.0$. Again one might expect that increased pressure would suppress hexene formation. The expected effect is observed at 700 F, is less pronounced at 800 F, and is actually reversed at 900 F. The effect of hydrogen-hydrocarbon ratio behaves similarly. In general, the same trends occur in the case of total naphthenes.

The cause of these abnormal effects is, of course, the presence of benzene in the system. Benzene formation is so sensitive to temperature, pressure, and hydrogen-hydrocarbon ratio that it tends to "funnel off" or "back up," as the case may be, the other components of the system. Such interactions can be easily overlooked if the complete system is not considered. They can be of considerable importance when, as is often the case, the amount of some minor component can have a critical effect on catalyst life.

Original presentation at API Division of Refining, Montreal, May 14, 1956.

TABLE 1
These Equilibrium Constants Were Used in the Calculations

COMPOUND	EQUILIBRIUM CONSTANT At 700 F	At 800 F	At 900 F
2-Methylpentane	1.50600	1.38190	1.29130
3-Methylpentane	0.81106	0.76095	0.71640
2,2-Dimethylbutane	0.88524	0.67343	0.54749
2,3-Dimethylbutane	0.45884	0.39276	0.34083
Cyclohexane	0.03170	0.06191	0.10956
Methylcyclopentane	0.22605	0.55861	1.20899
*1,1-Dimethylcyclobutane	0.00043	0.00121	0.00353
*cis-1,2-Dimethylcyclobutane	0.00120	0.00344	0.01005
*trans-1,2-Dimethylcyclobutane	0.00059	0.00172	0.00502
*cis-1,3-Dimethylcyclobutane	0.00059	0.00172	0.00502
*trans-1,3-Dimethylcyclobutane	0.00059	0.00172	0.00502
*Ethylcyclobutane	0.00160	0.00476	0.01487
Total substituted cyclobutanes	0.00500	0.01457	0.04351
1-Hexene	0.00037	0.00262	0.01403
cis-2-Hexene	0.00154	0.00921	0.04266
trans-2-Hexene	0.00180	0.01064	0.04714
cis-3-Hexene	0.00066	0.00389	0.01858
trans-3-Hexene	0.00093	0.00557	0.02495
2-Methyl-1-pentene	0.00575	0.03360	0.14251
3-Methyl-1-pentene	0.00087	0.00643	0.03670
4-Methyl-1-pentene	0.00028	0.00176	0.00832
2-Methyl-2-pentene	0.00826	0.04170	0.16775
3-Methyl-cis-2-pentene	0.00519	0.02708	0.10789
3-Methyl-trans-2-pentene	0.00788	0.04170	0.16764
4-Methyl-cis-2-pentene	0.00149	0.00857	0.03719
4-Methyl-trans-2-pentene	0.00211	0.01143	0.05042
2-Ethyl-1-butene	0.00173	0.00990	0.04581
2,3-Dimethyl-1-butene	0.00246	0.01320	0.05759
3,3-Dimethyl-1-butene	0.00013	0.00069	0.00309
2,3-Dimethyl-2-butene	0.00262	0.01228	0.04487
Total hexenes	0.04407	0.24027	1.01714
Cyclohexene	0.00057	0.00870	0.07418
*1-Methylcyclopentene	0.00188	0.01845	0.17148
*3-Methylcyclopentene	0.00025	0.00362	0.03651
*4-Methylcyclopentene	0.00028	0.00408	0.05272
*Methylidenecyclopentane	0.00013	0.00173	0.01770
Total unsaturated naphthenes	0.00311	0.03658	0.35259
*1-cis-3-Hexadiene	0.00000	0.00011	0.00213
*1-trans-3-Hexadiene	0.00000	0.00005	0.00113
*cis-2-cis-4-Hexadiene	0.00001	0.00025	0.00436
*cis-2-trans-4-Hexadiene	0.00002	0.00041	0.00715
*trans-2-trans-4-Hexadiene	0.00001	0.00017	0.00292
*2-Methyl-1-cis-3-pentadiene	0.00001	0.00039	0.00676
*2-Methyl-1-trans-3-pentadiene	0.00001	0.00031	0.00541
*3-Methyl-1-cis-3-pentadiene	0.00001	0.00039	0.00676
*3-Methyl-1-trans-3-pentadiene	0.00001	0.00031	0.00541
*4-Methyl-1,3-pentadiene	0.00001	0.00028	0.00476
*2-Methyl-1,3-butadiene	0.00000	0.00009	0.00174
*2,3-Dimethyl-1,3-butadiene	0.00001	0.00015	0.00250
Total hexadienes	0.00010	0.00291	0.05103
*Cyclohexadiene	0.00000	0.00021	0.00523
*1-Methylcyclopentadiene	0.00000	0.00011	0.00402
*2-Methylcyclopentadiene	0.00000	0.00011	0.00402
*5-Methylcyclopentadiene	0.00000	0.00002	0.00060
*3-Methylidene-1-cyclopentene	0.00000	0.00003	0.00131
Total C_6H_8	0.00000	0.00048	0.01518
Benzene	21.528	1121.9	32900.

* Estimated.

TABLE 2
Variation in Hexenes and Naphthenes

Temperature (Degrees Fahrenheit)	Pressure (Atmospheres Absolute)	Total Hexenes (Mole Percent) $r=0$	Total Hexenes (Mole Percent) $r=1.0$	Total Naphthenes (Mole Percent) $r=0$	Total Naphthenes (Mole Percent) $r=1.0$
700	8	0.33	0.22	1.94	1.29
	16	0.29	0.12	1.71	0.68
	32	0.25	0.07	1.48	0.38
800	8	0.76	0.78	1.97	2.02
	16	0.76	0.61	1.97	1.58
	32	0.68	0.35	1.75	0.89
900	8	0.61	0.68	0.80	0.88
	16	1.39	1.47	1.80	1.90
	32	1.48	1.29	1.92	1.68

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Meet the Author

EDWARD B. WEINBERGER, who presented this paper before the API in Montreal, joined Gulf Research and Development Company in 1943 as a physical chemist. He was designated mathematician in 1951 and became head of the Computational Analysis section in 1953. In this capacity he is responsible for the digital computer Gulf acquired in 1954. He received a degree in chemistry from Massachusetts Institute of Technology in 1941. The University of Pittsburgh granted him a M.S. in chemistry in 1947 and a Ph.D. in mathematics in 1950. He has been a lecturer in mathematics at the University of Pittsburgh since 1947, concentrating on numerical analysis since 1951.

More about computing . . .

Computer Solves Multicomponent Distillation Problems: Previous articles and reports on computers have fallen into three categories: (1) generalized discussions of the capabilities and potentialities of computers, (2) "data processing" applications, concerned primarily with the handling of large volumes of data, and (3)

"fragmentary" technical calculations, usually involving the solution of a single equation or set of equations. The difference between the program to be discussed here and other technical and engineering applications is summed up in the phrase "completely integrated;" all phases of the solution, including necessary assumptions, logic, and adjustment, are under control of the computer. The engineer need only supply the basic data essential to the problem. This data may vary over a wide range in its nature and extent; the computer will inspect the data and modify its own program, using available data, making assumptions where necessary, or even bypassing program blocks for which data are not available.

The particular problem being solved here is a multicomponent distillation, plate-to-plate calculation. The original data include only the independent variables necessary to define the problem. The computer makes initial assumptions, if needed, and then, by a series of trial and error calculations, proceeds to a complete solution of the problem. In the process of this solution, liquid and vapor rates from each plate are calculated by heat balance, tray temperatures are determined by bubble point calculations, and product compositions are adjusted to secure a feed plate match. Enthalpy and equilibrium data are evaluated as functions of temperature and concentration. The answers include over-all material and heat balances, temperature and vapor rate profiles, and liquid and vapor compositions on every plate. The program is completely general, and will handle "sloppy" separations as well as sharp ones.

An average problem, involving 15 components and 40 stages, requires approximately one hour for solution on a computer. The same problem would require 150-200 man-hours, using a desk calculator.

("Solution of multicomponent Distillation Problems on a Stored Program Computer," J. S. Bonner, Humble Oil & Refining Company, Baytown, Texas.)

Heat Exchanger Calculations Made Easier: Complete shell and tube heat exchangers are now being designed in a routine manner by The M. W. Kellogg Company on automatic digital computing equipment. Limitations of present equipment have restricted the applications to single phase, turbulent flow fluids in both shell and tube sides. Within this area, however, a wide variety of designs have been carried out, encompassing any combination of hydrocarbons, water, or water solutions as the heat-exchanging media.

With the acquisition of a magnetic drum-type calculation in the near future, it is anticipated that the program will be extended to include all combinations of single or multi-phase flow, in either the viscous or the turbulent region.

The use of computers in this application has resulted in three significant advantages:

1. *Schedules:* Use of the computer has enabled the heat exchanger engineers to meet schedules that would either not have been met, or which would have required extensive overtime.

2. *Costs:* Experience to date indicate that one computer hour is equivalent to about 15 man hours. This amounts to a saving of approximately a factor of four in the cost of designing a heat exchanger.

3. *Information:* The capacity to examine various alternatives in a given design has been greatly increased. Thus, for a given cost, it is possible to obtain more information more quickly than has previously been possible.

("The Design of Heat Exchangers on Automatic Computing Equipment," Alfred M. Peiser, The M. W. Kellogg Company, Jersey City, N. J.)

Computer Activities Are Growing: Automatic computation in the Shell organization has followed a pattern of conservative growth as a technical service. In general there have been three phases of development distinguished in part by the technical participation necessary for the application:

1. Applications replacing routine manual procedures for technical calculations requiring little or no human judgment in the execution of the computation program once developed. Examples of this type of computation are mass spectrometer calculations, pilot plant material balances, etc.

2. Applications in which human judgment appears in a definite capacity in developing the problem. These applications are not as routine as those in category 1 but still conform in general to certain basic methods of solution. Plate-to-plate distillation calculations and least squares techniques fall within this group.

3. More complicated applications requiring considerable technical judgment to establish a scientific approach for a particular result. Team approach is a common characteristic of this level of application because of the possible need for more than one technical skill in the formulation of a problem.

While examples for each of these stages are given, particular emphasis is placed upon three of the more complicated applications. These are:

1. Location for new refinery warehouse. This is based upon an analysis of a network of refinery supply distribution considering types of transportation, frequency of movement, and quantity of types of material needed.

2. Economic analysis of a thermal reforming and blending operation. Basically, the problem is to determine that set of conditions for which the value of the product from the unit minus blending and TEL expense is a maximum. Minimum lead requirements and maximum gasoline yields considering the external effect of available cat. gasoline and st. run naphtha are computed.

3. Lubricating plant storage program based upon operating schedules, feed availability, and market requirements.

("Growth of a Technical Computing Activity," T. H. Green, Jr. and C. M. Jones, Shell Oil Company.) # #

API Computer Session

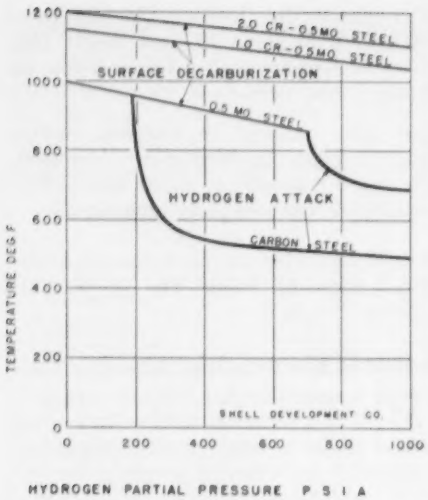

FIGURE 1—Operating limits for carbon and alloy steels in contact with hydrogen.

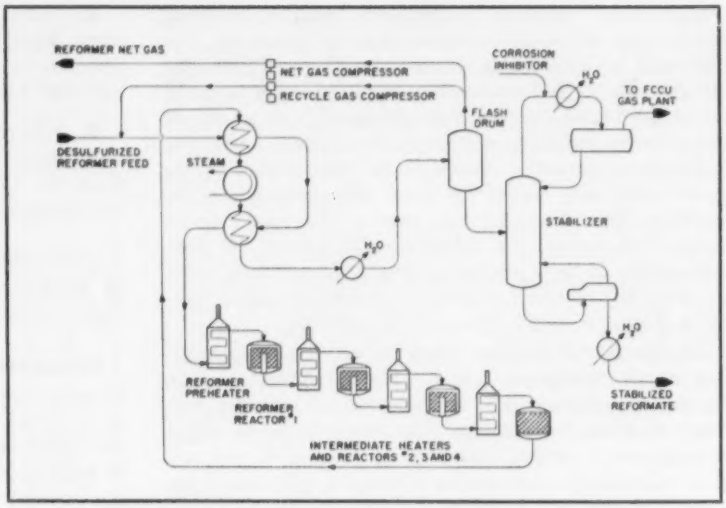

FIGURE 2—Catalytic reformer—simplified flow diagram.

Corrosion Session

Design for Minimum Corrosion

Here's how Richfield Oil Corporation planned its catalytic reformer for minimum corrosion. They anticipated maximum corrosion rates and made metallurgical selections.

B. W. Neumaier and C. M. Schillmiller
Richfield Oil Corporation, Wilmington, Calif.

THERE HAS BEEN unexpected high corrosion rates in commercial catalytic-reformer units, as a result of hydrogen sulfide, in the presence of hydrogen at temperatures of 700 F to 950 F and pressures over 200 pounds per square inch. The low-chrome steels, which has been found resistant in these media, were found not much more resistant than carbon steel to this new type of high-temperature corrosion. Consequently, the alloy section for the first reformers, based on conventional economic practices, was found entirely inadequate.

There are two types of corrosion about which something is not already known—hydrogen-sulfide attack in thermal- and catalytic-cracking units and hydrogen attack in ammonia plants and other hydrogenation processes. From this an analysis can be made of what happens when attack takes place by hydrogen sulfide and hydrogen simultaneously.

Hydrogen-Sulfide Attack—When hydrogen sulfide attacks steel, it combines with the iron and forms an iron-sulfide corrosion-scale layer. The rate of corrosion depends on:

- The hydrogen-sulfide concentration
- Temperature
- Pressure
- The permeability of the scale through which the iron ions diffuse outward and the sulfur ions inward.

The iron ions are believed to control the diffusion and corrosion rates.

Scale Stability—Scale stability is desired in reducing corrosion rates. Once a dense iron-sulfide scale is established, continuous corrosion proceeds at a low rate. In operation, scales can be jarred loose by (1) mechanical means, (2) rapid temperature changes, or (3) oxidation. Removal of the protective sulfide scale exposes bare metal to the returning sulfide reactions.

Hydrogen Attack—The chemical activity of hydrogen depends on its temperature and pressure. Above 500 F molecular hydrogen will dissociate slightly and will provide atomic hydrogen. When present in large quantities, hydrogen can cause embrittlement or it may react with carbon and sulfur to form gas pockets at pressures sufficiently high to cause internal rupturing. Damage shows as decarburization and intergranular cracking.[1,2]

Nelson's Graph—The effectiveness of carbide-stabilizing elements in steel has been evaluated. In a report on this, G. A. Nelson[1] presented a graph defining the safe

operating limits for carbon and low-alloy steels. (Figure 1) These data have been used as a basis for the design of many high-pressure-high-temperature hydrogen processes and in no instance, where the requisite alloy content has been adhered to, has hydrogen damage been reported.

When observing the curvature of the carbon-steel line in Figure 1, it is of interest to note the quite sudden and very rapid decrease in resistance to corrosion at a hydrogen partial pressure of approximately 200 psi.

Hydrogen-Sulfide-Hydrogen Attack—Under the conditions of reforming, hydrogen sulfide is formed from the sulfur in the charging stocks. These factors determine the unexpected high rates of corrosion in this environment.

Mechanism Differences—At near-atmospheric pressures, the stability of steel against hydrogen sulfide increases with increasing chromium content. Dittrich's work[3] showed that under pressure at elevated temperature the low-chrome steels, with up to 10 percent chromium, were more vigorously attacked than carbon steel. The present thinking is that the sulfide-forming iron migrates outward, while the chromium atoms are left behind in the steel.

High Corrosion Rates—A definite lack in scale stability in many applications becomes worse with an increase in temerature. Corrosion rates as high as 0.30-inch per year have occurred on low-chrome steels in reformer equipment operating at 950 F, with 0.8 percent by volume of hydrogen sulfide present. Corrosion rates diminish with scale thickness.

DESCRIPTION OF RICHFIELD'S UNITS

Richfield Oil Corporation's catalytic-reforming unit will have a charge capacity of 17,000 barrels per day and is scheduled for completion in June of this year. The reformer feedstock, which consists of straight-run naphtha and viscosity-breaker naphtha, requires pretreating in a hydrodesulfurization unit. This pretreatment saturates olefins in the cracked components of the feed and removes sulfur, nitrogen, and other reformer-catalyst contaminants. Process flow of the reformer and desulfurizer processes are shown in Figures 2 and 3.

Operating Conditions—The desired reactions in these units require elevated temperatures and high hydrogen partial pressures are necessary. The reformer-reactor inlet temperatures will range between 900 F and 975 F, depending upon the catalyst activity and the reformate octane desired. The desulfurizer-reactor temperature will be approximately 780 F. In both processes a high partial pressure of hydrogen is required. This is accomplished at moderate pressures, by using a high molal recycle-gas ratio, which increases the hydrogen concentration.

MINIMIZE HIGH-TEMPERATURE SULFIDE CORROSION

The steps which can be taken to minimize sulfide corrosion are:

1. A change in the environment, such as the removal of hydrogen sulfide.
2. The use of corrosion-resistant materials.
3. The providing of a barrier between the corrosive fluid and base metal, such as aluminum coating.

Richfield Oil Corporation ruled out aluminizing since much depended on the method of application and the type of process used and no long-term operating experiences were available at that time.

Variables Influencing Corrosion Rates—There are several factors or variables which influence the rate of corrosion—duration of exposure, total system pressure, temperature, concentration of hydrogen sulfide, and materials of construction.

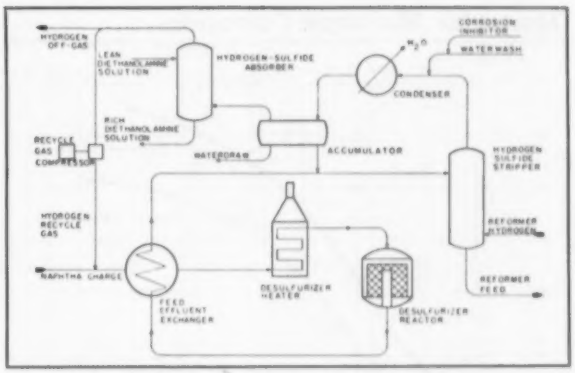

FIGURE 3—Hydrodesulfurizer—Simplified flow diagram.

In order to plot corrosion rates on a simple graph, three of these variables have to be eliminated or fixed. Two noteworthy systematic investigations of the influence of all these variables on corrosion have been carried out.[3, 4]

By thus "fixing" the first two variables—time of exposure and pressure—the rates of corrosion, as affected by material and hydrogen-sulfide concentration, could then be plotted for the average reformer-reactor and desulfurizer-reactor temperatures. Corrosion-rate curves were developed on the best information which could be obtained from private contacts with other refineries.

Anticipated Maximum Corrosion Rates—The materials of construction were grouped in three categories with increasing corrosion resistance: Carbon steel and low-chrome steels, the 12-percent chrome steels, and the 18-8 chrome-nickel alloys.

No significant difference in corrosion rates was found for the group of 0 to 9 percent chrome steels; they exhibited the poorest corrosion resistance.

The intermediate group of 12 percent chrome steels exhibited under mild conditions, i.e., at moderate temperatures and low hydrogen-sulfide content, corrosion rates which were approximately 50 to 65 percent of those experienced with low-chrome steels.

The 18-8 chrome-nickel alloys have consistently provided the best corrosion resistance.

Corrosion rates were found to increase very rapidly with hydrogen-sulfide concentrations in the range from 0.01 to 0.10 percent by volume. At 1.0 percent by volume the rate is approximately double what it is at 0.1 percent by volume. Relatively little increase is found in the range from 1.0 to 10.0 percent by volume. Figures 4 and 5 give the curves showing the anticipated maximum corrosion rates in catalytic-reforming and in hydrodesulfurization equipment.

Hydrogen Sulfide Removal—The quantity of sulfur in the feedstock and the recycle-gas ratio fix the hydrogen-sulfide content in the recycle gas and, thereby, the hydrogen-sulfide concentration in the whole high-temperature system. Because of the high recycle ratios generally employed, even a low sulfur concentration in the feed can create high hydrogen-sulfide concentrations in the system. Amine scrubbing of the recycle gas for hydrogen-

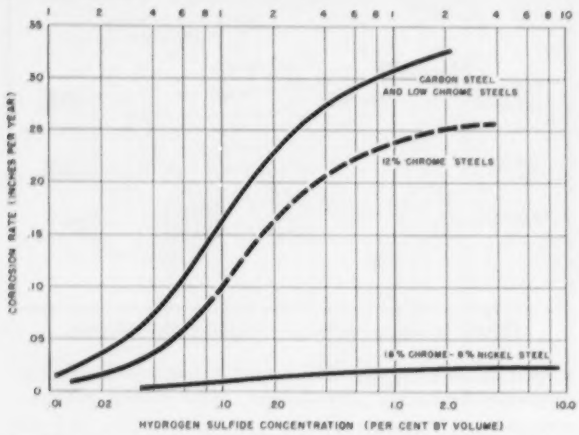
CARBON STEEL AND LOW CHROME STEELS
12% CHROME STEELS
18% CHROME - 8% NICKEL STEEL
CORROSION RATE (INCHES PER YEAR)
HYDROGEN SULFIDE CONCENTRATION (PER CENT BY VOLUME)

FIGURE 4—Anticipated maximum corrosion rates in catalytic-reforming equipment.

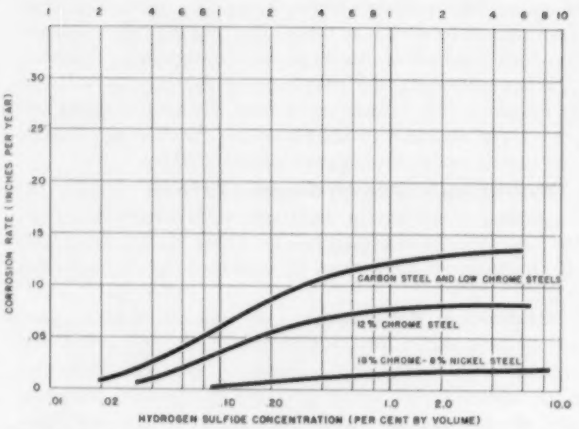
CARBON STEEL AND LOW CHROME STEELS
12% CHROME STEEL
18% CHROME - 8% NICKEL STEEL
CORROSION RATE (INCHES PER YEAR)
HYDROGEN SULFIDE CONCENTRATION (PER CENT BY VOLUME)

FIGURE 5—Anticipated maximum corrosion rates in hydrodesulfurization equipment.

sulfide removal eliminates the major influence of the recycle ratio, and a marked improvement in corrosion rates can be obtained.

Basis of Metallurgy Selection—Richfield Oil Corporation's metallurgy was selected on the basis of a maximum allowable corrosion rate of 0.05 inch per year for vessels, furnace tubes, and transfer lines, and of 0.03-inch per year for heat-exchanger tubes. In the radial-flow reactors, allowance was made for scale collection and no high-pressure drops across the reactor beds are anticipated.

Reformer Metallurgy—By hydrodesulfurization of the reformer feedstock the sulfur content in the naphtha will be reduced from 0.35 to below 0.01 percent by weight. For this low-sulfur feedstock the hydrogen-sulfide concentration in the reformer system will approximate 0.015 percent by volume. Figure 4 indicates that, for this concentration of hydrogen sulfide, low-chrome alloys can be used safely.

Amine Scrubbing of Desulfurizer Recycle Gas—Hydrodesulfurization of the reformer feedstock substitutes a severe corrosion problem in the reformer at 950 F for a milder one in the desulfurizer at 780 F. Because of the lower temperature, corrosion rates are approximately 60 percent less. The sulfur content in the combined straight-run naphtha and viscosity-breaker naphtha feedstock to the desulfurizer is expected to be approximately 0.35 percent by weight. This would bring the hydrogen-sulfide content in the hydrogen recycle stream to approximately 0.78 percent by volume. Figure 5 indicates that this concentration, even at 710 F, can cause corrosion rates in the heater tubes as high as 0.10 inch per year unless high-chrome or stainless steels are employed. Corrosion rates in the reactor-effluent transfer line and heat exchangers would be even higher. Amine scrubbing of the desulfurizer recycle gas has been deemed compulsory economically. It is estimated that the hydrogen-sulfide removal on the recycle stream will reduce the hydrogen-sulfide content to below 0.012 percent by volume in the recycle gas, to 0.010 percent by volume in the combined feed, and to 0.25 percent by volume in the desulfurizer-reactor effluent.

Desulfurizer Metallurgy—Even should 10 percent of the sulfur in the naphtha feedstock crack to hydrogen sulfide in the heater, predicted maximum corrosion rates from Figure 5 are still low enough to permit the use of low-chrome steels in heater tubes and transfer lines ahead of the reactor. The metallurgy is shown in Figure 7.

Other Features—Scale stability is desirable in minimizing corrosion rates. Oxidation causes scales to shrink and spall off and expose bare metal to high initial corrosion rates by the returning sulfide reaction. For this reason, alternate oxidizing-reducing conditions in the heaters are avoided in the regeneration step. Also, air is excluded from the feed tanks by gas blanketing, which reduces the fouling of heat exchangers and heater tubes.

CONTINUOUS CORROSION EVALUATION

Preparations have been made for continuous corrosion evaluation. The severity of corrosion can be diagnosed from operating conditions, quantitative analyses for corrodents, and corrosion-rate measurements. There is enough flexibility allowed for in design to take counteracting steps if necessary, without waiting for damage to appear at inspection.

Allowance has been made at the units for 1-inch valved connections, so that samples of feed, products, and all intermediate streams can be obtained to determine the concentrations of corrodents present.

Objectionable corrosion rates may still be experienced in heaters, feed-effluent exchangers, and transfer lines over 600 F. The continuous determination of corrosion rates by installing 1-inch bypasses around the first exchanger in the reactor-effluent lines of the reformer and desulfurizer is being studied. In these bypass lines will be located a 3-inch diameter spool section, with a blind flange for insertion and removal of test coupons. A similar bypass may be installed in the line from the desulfurizer heater to reactor. The bypasses will be blocked with 1-inch valves. High-temperature corrosion can be kept to a minimum by proper operation of the hydrodesulfurizer, amine-scrubbing system, and hydrogen-sulfide stripper. Continuous stream analyses will help to control operation of the units.

Low-Temperature Corrosion—Serious damage can

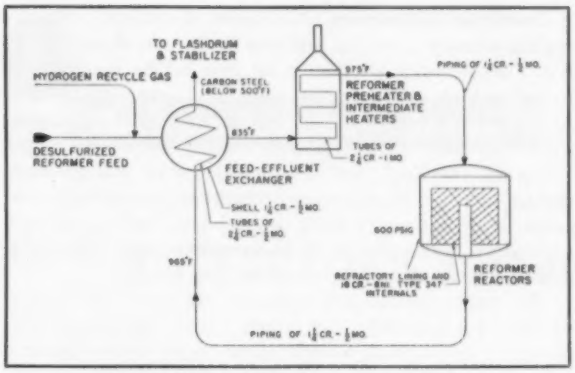
TO FLASHDRUM & STABILIZER
HYDROGEN RECYCLE GAS
CARBON STEEL (BELOW 500°F)
975°F
PIPING OF 1¼ CR - ½ MO.
REFORMER PREHEATER & INTERMEDIATE HEATERS
DESULFURIZED REFORMER FEED
835°F
TUBES OF 2¼ CR - 1 MO.
FEED-EFFLUENT EXCHANGER
SHELL 1¼ CR - ½ MO.
TUBES OF 2¼ CR - ½ MO.
600 PSIG
965°F
REFRACTORY LINING AND 18 CR - 8Ni TYPE 347 INTERNALS
REFORMER REACTORS
PIPING OF 1¼ CR - ½ MO.

FIGURE 6—Catalytic reformer—metallurgy.

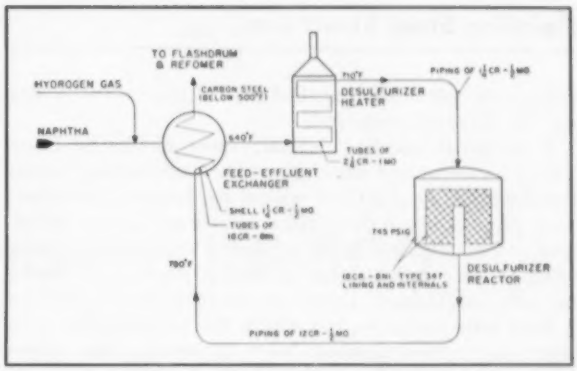

FIGURE 7—Hydrodesulfurizer—metallurgy.

occur by aqueous hydrogen-sulfide attack in the hydrogen-sulfide stripper overhead system, where a water wash will be applied to remove ammonia. The environment here is also conducive to hydrogen blistering. Three hydrogen probes will be installed in the condenser effluent stream and in the vapor and water phases of the overhead accumulator.

The second location where low-temperature corrosion may occur is in the reformate stabilizer and overhead system. At both locations a 1-inch valved connection was installed ahead of the overhead condenser so that a corrosion inhibitor can be introduced without delay if experience dictates the need. In addition, several 1-inch valved locations are allowed for a retractable corrosion-meter probe. This corrosion meter, or corrosometer, permits corrosion rates to be read continuously and are related to a change in the electrical resistance of a wire in the corrosive medium. Standardized 1-inch valved connections for sample locations and hydrogen-probe locations can also be used for corrosion-rate measurements.

PERFORMANCE EXPECTATION

The approach applied to minimize corrosion troubles is in line with conventional economic practices. Based on presently available information the aforementioned steps have been taken. The selections now incorporated may not be the final answers, and much is still to be learned from our experience and that of others.

Corrosion control has been applied in the design stage of the unit, and hoped to be successful. Facilities were incorporated to determine rates of corrosion on a continuous basis so that, with the analyses for corrodent concentrations, a corrosion study can be carried out.

The unit is to be kept sufficiently flexible in operation so that the corrosion rates can be lowered if needed. Shutdown cycles should be determined by catalyst activity and a preventive maintenance program will be adhered to.

Original presentation was before the API Division of Refining meeting, Montreal, May 14, 1956.

ACKNOWLEDGMENT

The authors wish to express their appreciation to Richfield Oil Corporation for permission to publish this paper. Thanks are due to E. C. Herthel for his guidance in the planning and coordination of all phases related to the new units, including the corrosion study. We are indebted to Sinclair Research Laboratories for use of some of their corrosion-rate data.

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Meet the Author

CHARLES M. SCHILLMOLLER received his early education in Holland and the Netherlands East Indies; served with the Netherlands' air force during World War II, and completed his education at Australia's University of Sydney, where he received a B.E. degree in chemical engineering in 1952. That same year, he joined Richfield Oil Corporation as a process engineer at its Wilmington, Calif., refinery. Since May 1954, he has been specializing in corrosion-control problems. Mr. Schillmoller, co-author of this paper, made the presentation in Montreal.

Painting...Middle-East Problems...and Graphitization of Steel...

Painting Steel Structures—Corrosion of petroleum refineries costs over $270 million per year. The amount of corrosion is controlled to a marked degree by the type of crude or stock being worked. Some stocks, noncorrosive themselves, cause corrosion through the water, oxygen, salt, or decomposition products accompanying the processing. Severe corrosive conditions may require the use of corrosion-resistant alloys or lining, but painting is still the most favored method of preventing corrosion. Aside from painting for appearance, this method is considered economical for most of the exposed steel in refin-

API Corrosion Session

Painting Steel Structures . . .

eries, even where the installed cost of the steel is as low as 15 to 20 cents per pound.

Economical painting actually saves money by being both functional and decorative. The outstanding factors deciding the life of a paint system are design of the structure, preparation of the surface, selection of correct paint, and proper application. In preparing the surface, weathering is an excellent method only if the steel is subsequently sandblasted. Intact or sound millscale provides a good base for paint, but rust is the poorest surface to paint over. Pretreatments such as wetting oils, phosphates, and wash primers give excellent results when used correctly. The selected paints must be compatible with the surface preparation and pretreatment. The oil-base paints are unexcelled for wirebrushed steel although their chemical resistance is low. Synthetic resin paints—alkyds, phenolic, vinyls, chlorinated rubbers, epoxides, and bituminous mastics, require a blast cleaned or pickled surface for long life. Service environment is an important factor in the selection of paints since the more corrosive the exposure, the more chemical resistance is needed in the paints. Vinyls have been particularly successful in such corrosive service. Mastics are also good (except for sharp edges and crevices), and limited experience with epoxides and chlorinated rubbers shows excellent promise of fine performance. Specifications covering complete paint systems are now available, and their use is recommended for simplifying procedures and reducing paint costs.

A guide for preparing painting specifications is available. It insures the use of proper materials and suitable surface preparation.

("Painting of Steel Structures in Petroleum Refineries," J. O. Jackson, Pittsburgh-Des Moines Steel Company, Pittsburgh, Pa., and Joseph Bigos, Steel Structures Painting Council, Mellon Institute of Industrial Research, Pittsburgh, Pa.)

Processing Middle-East Crude—Since the end of World War II, new types of crude oil coming from the Middle East are being processed in increasing quantities. In addition to the normal contaminance, such as salt water, these crudes contain a very high percentage of sulfur. When the N. V. De Bataafsche Petroleum Maatschappij, The Hague, of the Royal Dutch/Shell Group, designed their plant for the processing of these Middle East crudes, account was taken of the fact that, during distilling, severe corrosion could be caused by hydrochloric acid as well as by the sulfur products formed from the crudes.

Because corrosion resistant alloys were difficult to procure during the building program, other ways had to be found to solve the potential corrosion problems. It was proved that, by modifying the operating conditions and by making use of an adequate neutralization system, the use of unalloyed steels was entirely feasible. Experience gained during the last six years in such modified plants is given in the paper.

("Corrosion in Distilling and Vacuum Distilling Plants for the Processing of Middle East Crude Oil," W. A. Derungs, N. V. De Bataafsche Petroleum Maatschappij, The Hague, The Netherlands.)

Catalytic Reformers—Corrosion in catalytic reformers has become a serious problem in the petroleum industry. The corrosion product is an iron sulfide scale which forms at high temperatures when hydrogen sulfide, in a hydrogen-rich atmosphere, reacts with the commonly used materials of construction. Usually the actual metal loss is not very high, but the corrosion scale will spall off during changes in operating conditions and shutdowns. Loose scale interferes with normal unit operations and ultimately causes plugging. The resultant unit downtime and necessary cleaning procedures are costly.

This paper summarizes corrosion test results on a wide variety of commonly used steels. These data were obtained in commercial Sovaformers (static bed reformers utilizing a platinum-type catalyst). Test periods from 50 days to seven months are covered for different type charge naphthas.

In addition to the results in commercial units, laboratory corrosion data are summarized for comparison with the field results. In order to extend available information in this subject, previously unreported laboratory corrosion data are also included.

("High Temperature Hydrogen Sulfide Corrosion in Commercial Sovaformer Units," E. B. Backensto and R. D. Drew, Socony Mobil Laboratories, Research and Development Department, Paulsboro, N. J.; and J. N. Vlachos, Soconey Mobil Oil Company, Inc., 26 Broadway, New York, N. Y.)

Graphitization of Steel—This is a summary report of the work of the Subgroup on Deterioration of Steels, the Subcommittee on Unfired Pressure Vessels, and the Committee on Refinery Equipment.

Previous work which has been done on the graphitization of steel in petroleum refinery equipment (a report on this subject was delivered as a paper at the 1955 API Refinery Midyear Meeting) shows graphitization has taken place, although no chain or eyebrow graphite was encountered in any of the 554 samples examined. However, the presence of nodules of graphite and the breakage of samples under conditions of the bend test suggested to the Subgroup on Deterioration of Steels at High Temperatures of the Pressure Vessel Committee that further work should be done to test the stress rupture properties of graphitized welded plates.

Specimens of slightly graphitized, moderately graphitized, and severely graphitized steels were obtained. Samples from the unwelded portions of the plates and samples obtained from the welded joints were tested under stress rupture conditions; and the mechanical properties of the base plates and the graphitized welded joints are compared.

While it is unwise to draw too many conclusions from such a limited program, it can be said that no loss of strength has been encountered in the specimens when the welded joint is compared with the unwelded plate. Due to the uncertain past history of the specimens and to the limited time duration of the tests, no attempt is made to compare the plates tested with new plate.

("The Effects of Graphitization on the Stress-Rupture Properties of Welded and Unwelded Plain-Carbon Steels," J. G. Wilson, Shell Oil Company, New York, N. Y.)

##

Electrical Equipment Session

A Contractor's Reaction to RP-500

Here are the advantages and disadvantages of this API standard. Actual case histories illustrate the effects of adopting this criteria.

James T. Pringle
Bechtel Corporation
San Francisco, Calif.

THE COMMENT most heard about API Standard RP-500 is that "such a guide is long overdue." Many of the provisions in this standard closely parallel the preferred practices developed over the years. It is believed that this standard will be received favorably and adopted by the refinery industry.

The first duty of the contractor's electrical engineers is to prepare a preliminary single line diagram and an electrical plot plan. Hinged upon the acceptance of this single line diagram and electrical plot plan are:

- Preparation of all electrical specifications
- Preparation of material requisitions and selection of electrical equipment

The electrical plot plan actually determines two things:

- Physical extent of hazardous areas
- Degree of the hazard, e.g., Division 1 or Division 2

These restrictions must be established before much more than a general electrical scheme can be developed.

The most difficult decision to make involves the designation and classification of the hazardous areas. There are more methods of classifying these areas than there are owners of plants. On some occasions considerable time is lost while reaching agreements on the limits of these areas. The definition of these limits must become firm before any design work can commence.

Examples of Past Practices—The following examples illustrate the arbitrary manner in which hazardous areas are sometimes classified.

Case A: A line was drawn by the client along what seemed to be a rather arbitrarily chosen coordinate on the plot plan. One side of the line was to be considered Division 2; the other side, nonhazardous. As a result, several large gas compressors were in a Division 2 atmosphere and their controls, a few feet away, were in a nonhazardous atmosphere. It might just as easily have been the opposite way, requiring explosion-proof control equipment. Furthermore, a short offset was later made in the straight line in order to put the boiler plant in a nonhazardous atmosphere.

Case B: The electrical classification of refinery areas was determined by the safety engineer. Although he was undoubtedly guided by sound judgment, his criteria were known only to himself, and it is impossible for an engineering contractor to determine in advance what areas must be considered hazardous. This introduced an element of uncertainty which could delay electrical design and material procurement.

Case C: After discussions among those concerned, the electrical specifications were written so that:

1. *Division 1* locations were the TEL plant, the truck-loading racks, and the LPG plant.
2. *Division 2* locations were the tankage areas, process areas, and transfer-pump slabs.
3. *Nonhazardous* locations were pressurized buildings, areas 100 ft. or more from a Division 1 source of hazard, and areas 50 ft. or more from a Division 2 source of hazard.

However, it was stipulated that no plot plans were to designate the area classifications. After drafting was well along, the TEL plant and the truck-loading racks were changed by the client from Division 1 to Division 2 and then back to Division 1. The truck-loading racks finally settled down as Division 2 in order that tank-truck engines would not be required to have explosion-proof exhausts and ignition systems.

Case D: The client's specifications prepared for this job stated that:

1. A *hazardous* location was Class I, Division 1, as specified in the *National Electrical Code* (NEC).
2. A *semihazardous* location was Class I, Division 2, as specified in the NEC.
3. *Nonhazardous* areas were to be designated at the time the contract was let.

Although no argument could be given against these statements, they do nothing to classify a specific area on the plot plan. Further clarification came much later in the electrical specification developed by our company which provided that:

1. *Division 1* areas would be all buildings or confined spaces where accumulations of explosive gases could reasonably occur.
2. *Division 2* areas would be all naturally ventilated open areas within the plot limits of process areas; the

truck-loading racks; gasoline and crude-oil storage facilities; effluent area; dock; and parts of the laboratory, garage, and hospital.

3. *Nonhazardous* areas would be pressurized buildings and generally all areas outside the plot limits and not otherwise classified.

There was no firm definition of what constituted "plot limits." Although a conventional-type substation was located immediately inside what appeared to be the plot limits of a process area, it was close to a furnace and presumably could do no harm.

Case E: Within the process-plot limits, Division 2 classification prevailed except where circumstances indicated it should be Division 1. The roadways were considered nonhazardous zones, and the electrical manholes were on the road center line. Because of its proximity to the process area, the narrow strip between the plot limit and the edge of the road was designated Division 2.

Case F: Except for any enclosed buildings which are of necessity Division 1, a typical process plot is considered Division 2 to a line 25 feet outside the equipment-edge line. The so-called plot limit may be from 10 feet to 25 feet outside the equipment-edge line. Thus the Division 2 area may extend several feet beyond the plot limit. In most cases there is still room for an area substation in the nonhazardous zone between the 25 foot line and the roadway.

The preceding examples are actual cases each differing significantly from the other. In some of them the area classifications would seem to an outsider to be made on a somewhat arbitrary and elastic basis. In others the basic pattern is fairly firm, but with certain indeterminate twilight zones between Division 1 and Division 2, and between Division 2 and nonhazardous areas.

In most cases a Division 1 area is as delineated in RP-500, except that little notice has been paid to points below grade in Division 2 areas. Very seldom has much been said about tankage areas, except to indicate that a hazard does exist. It is in defining the physical boundaries of Division 2 atmospheres, particularly their vertical extent, that the greatest differences exist between these specific cases and the recommendations of RP-500. An observation of many refinery properties indicates that they generally over-apply explosion-proof equipment and wiring even on the basis of their own specifications.

Effect of RP-500 on Equipment Used—Adhering to the recommendations of RP-500 in the foregoing cases could have the following effects on the choice and installation of electrical equipment.

► **Lighting—Little Effect**—As in the past, lighting fixtures in nonpressurized buildings in hazardous areas would be explosion-proof. Although the extent of the Division 2 areas has been generally increased by RP-500, this would make little difference in practice. Vapor-tight fixtures are usually used for general outdoor lighting. Conventional floodlights and street lights would continue to be adequate since they are generally above the Division 2 area.

► **Motors—Some Increase**—Motors in nonpressurized buildings in hazardous areas would continue to be explosion-proof. In addition, those in pump pits or sumps would have to be explosion-proof, instead of often merely totally enclosed as in the case of water pumps. Since a squirrel-cage motor in any type of enclosure meets NEC requirements for a Division 2 area, the enlargement of such areas would not affect the choice of motors.

► **Panel Boards and Motor Control—15-60 Percent Increase**—Most types of lighting panels, motor starters, and circuit breakers now available for Division 2 locations are of the explosion-proof type built for Division 1 use, plus the oil-immersed, corrosion-resistant construction which is sometimes acceptable. Hence the enlargement of the Division 2 zone would increase the cost of such equipment. That is, a rack or assembly of weatherproof equipment is now sometimes located between the plot limit and the roadway.

Since this equipment is usually less than 50 feet from a possible source of hazard, explosion-proof or other enclosures suitable for Division 2 use would be required to comply with RP-500. This would increase the installed cost of motor-control equipment approximately 15 percent to 25 percent, and the installed cost of lighting panels approximately 60 percent. In addition, certain conveniences and advantages of the nonexplosion-proof equipment would be lost.

► **Conduit Devices—Least Effect**—Since round, threaded-cover, explosion-proof conduit fittings are often used instead of the vapor-tight type in all outdoor locations in a refinery, any change in the relative size of Division 1 or Division 2 areas would make little difference. There might be a small increase in the number of sealing fittings used, but this would be insignificant.

► **Power Distribution—Greatest Effect**—The chief impact of RP-500 would be on the electric power distribution system.

Substations are frequently situated between the plot limit and the roadway, and not always 50 feet from the closest source of hazard. Often they could be relocated, with only minor extra expense for additional lengths of feeder cables and conduits. But the arrangement of the process plots might force the removal of a substation to a more distant and less desirable location, which would greatly increase cable and conduit lengths.

A duct and manhole system under or along the roadway past any process area may fall within the 100-foot zone, and hence would have to be suitable for Division 1. Since there is no obvious way to make a manhole explosion-proof, this type of distribution system could not be installed. A similar condition could arise in an existing refinery where it might be desired to build a new process unit in a vacant area bounded on one or more sides by a duct and manhole system lying within this 100-foot zone.

Subfeeders or motor feeders within a process area could not be run in underground conduits if the length of run or the number of offsets would require handholes or pull boxes at or below grade.

For a distribution or motor-feeder system requiring relatively few high-voltage cables, underground ducts with weatherproof pull and splice boxes located more than two feet above grade could be installed at no greater cost than the manhole or handhole type of construction. To find the space for these boxes often presents a problem.

A conduit and pull-box system on overhead pipeways, such as some refineries now use, is an alternative. The cost of such an installation varies widely, depending on the availability of usable pipe supports installed for other

purposes, and the extent to which fireproofing is applied; but it will cost upward of twice as much as an underground system.

Another alternative is a system often used in other countries where armored cables are laid in sand-filled precast-concrete trenches set with their concrete covers at grade. Under favorable conditions this system may cost 10 percent less than a conventional duct and manhole system, and it offers good flexibility for future changes and additions. Possibly greater consideration should be given in the the U. S. to the use of such a type of construction.

To summarize, the creation of a Division 1 condition below grade at roadways and in process areas would require certain design changes in most distribution systems. A suitable system might then cost from very slightly less to considerably more money, depending on the type of installation usually used by a specific refinery and the modifications the refinery might adopt.

RP-500 Can Help—A uniform method of classification of hazardous areas is desirable. The approach heretofore has been quite individualistic and at times seemingly inconsistent. The entire industry can never be bound rigorously by one set of classification criteria; but it can be hoped that some fixed starting point (such as RP-500) might be accepted.

If RP-500 were generally followed, the engineering contractor could promptly . . .

- Start the electrical design
- Write specifications
- Requisition material

From the electrical designers standpoint, this would mean . . .

- A small saving in money
- A modest saving in time
- A tremendous reduction in confusion that eventually would save the client money.

RP-500 Did Help—The design of a process area for a petrochemical plant was just getting under way. In a rather general way, one large outdoor area had been designated Division 1 by the client, and two smaller areas had been classified Division 2. In a conference with the client's representatives, they were asked for more specific information on the extent of these areas. They asked if we were familiar with RP-500. When we replied that we were, they told us to follow its recommendations to determine the limits of the hazardous areas. Thus, in a moment's time, we had obtained a complete answer which was clear and precise. It was immediately possible to locate the unit substations so they would not be in a Division 1 area, and to determine which starter groups would be in a hazardous and which in a nonhazardous location.

Conclusion—If the generally accepted standard is to be RP-500, then it appears that construction costs in process areas would generally be somewhat increased. However, this would be a very small percentage of the cost of the entire refinery electrical installation.

Original presentation was before Electrical Equipment session, Twenty-First Midyear Meeting, API Division of Refining, Montreal May 14, 1956.

Meet the Author

JAMES T. PRINGLE received a B.S. degree in electrical engineering from Washington State College in 1928. His background in electrical engineering includes ten years with Westinghouse Electric Corporation, three years with Reading Railroad and two years with Pennsylvania Railroad. Since 1950, he has been with the Electrical section of Bechtel Corporation's Refinery Engineering division.

A refiner's experiences with RP-500 . . .

API Standard RP-500: *Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries* provides a basis for consistent and accurate determination of existence, degree, and extent of hazardous areas in petroleum refineries. When this publication became available, the Engineering and Construction department of The Atlantic Refining Company adopted RP-500 as a basis for classifying refinery areas for purposes of electrical installations. A procedure involving recommended classification by key electrical supervisory personnel, with review and approval at the managerial level, has been developed. Detailed designs are then prepared in accordance with the approved area classifications. A typical example illustrating the use of RP-500 in classifying areas and the procedures employed by Atlantic will be discussed. Special problems such as those created by furnaces, internal combustion engines, proximity to roadways, and difficulties encountered in existing plants where space is at a premium will be reviewed.

("A Refiner's Experiences in Using API Standard RP-500," F. C. Somers, The Atlantic Refining Company, Philadelphia.)

Division 2 Problems: In petroleum refineries there are areas which can be classified as hazardous (Division 1), semi-hazardous (Division 2), or non-hazardous. Electrical equipment is generally available for both extreme conditions, but there is a definite lack of equipment especially designed for semi-hazardous locations. Not even the criteria for this equipment have been clearly established. This paper discusses the reasons for this situation, why more Division 2 apparatus is now required, and suggests steps for correcting the condition.

("Problems in Providing Suitable Electrical Equipment for Class I, Division 2 Areas," Earle R. Hoyle, Sinclair Refining Company, East Chicago, Ill.)

API Electrical Equipment Session

The Ideal Preventive Maintenance Program Should Include:

1. **Design and material controls**
2. **Operating procedures**
3. **Records**
4. **The extent of the program**
5. **The accounting system**
6. **Maintenance organization and procedure**
7. **Reports**
8. **Personnel**

Maintenance Session

Preventive Maintenance in Action

Here's how the principles of an ideal preventive maintenance program were applied successfully in a large west coast refinery.

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HOW CAN A PREVENTIVE maintenance program be developed to maintain a plant at optimum cost? Here are all the factors that need be considered to get the most favorable cost and how Tide Water Associated Oil Company has applied them at its Avon refinery.

A preventive maintenance program attempts to solve the problem by providing for planning and scheduling of the following:

1. Routine inspections while equipment is operating
2. Short-term shutdowns or outages for the purpose of inspection and minor maintenance
3. Overhauls

It is solved if, through the inauguration of such a program, the prevention of unscheduled breakdowns of uncertain duration and seriousness results in decreased operating costs, increased production, and added protection for capital investment.

Design and Material Controls—Preventing excessive maintenance begins with design on the drawing board and at the engineer's desk.

Equipment is selected not only on the basis of first cost; potential operating costs, including maintenance, are given major consideration. Accessibility and handling fa-

cilities for performing maintenance are items of importance in laying out new installations.

Design standards and specifications are essential for the guidance of buyer and vendor.

In selecting equipment, provision is made for adequate corrosion and erosion protection.

Standardization and interchangeability of parts are accomplished to the fullest extent possible in order to keep the inventory of spare parts and stock materials to a minimum.

A storehouse inventory-control system is essential. Such a system includes a complete spare-parts and stock catalogue, copies of which are widely distributed and kept current. This assists in cutting the costs of the maintenance program by controlling the availability of material and expediting its delivery to maintenance jobs.

Operating Procedures—Written standard operating instructions are in effect and they provide for the following: 1. Starting up 2. Continuous operation 3. Shutting down 4. Lubrication 5. Emergencies, 6. Testing.

Operating personnel agree to the formulation of routine and overhaul preventive maintenance schedules and to adhere to them as closely as possible.

Installations are provided with proper instruments and controls for indicating, recording, and controlling performance; for giving adequate warning of breakdown; and for preventing the type of failure which endangers life and property.

Records—An inventory of all equipment in the plant is made and recorded on equipment cards. Each piece of equipment has a separate card, with an identifying inventory or equipment number. Each card includes the following data: a brief description of the equipment and its service; names of the manufacturer and vendor, or agent; manufacturer's serial number; purchase order number; work order number; date of installation; investment cost; drawing numbers for the installation and for the spare-parts list; performance data; and pertinent information on materials of construction.

Space on the card is also provided for recording changes from the original location and service. The card described is the equipment-data card, which may also serve as a plant-property record showing original and additional installation costs.

Attached to each data card, or closely identified with it, is a maintenance-record card on which is recorded such items as the following: labor and material costs by the month or year; yearly depreciation; inspection schedule; and lubrication schedule.

Extent of Program—The next step involves a study to determine what existing equipment is to be placed under the preventive maintenance program and scheduled for inspection, routine maintenance, and overhaul. Only those items of equipment are included which justify this step economically. The cost of preventive maintenance for a piece of equipment, or class of equipment, is estimated and compared with the over-all cost in case of a breakdown. The savings in preventing a breakdown are the criterion for inclusion in the program.

In some cases it is less expensive to let a piece of equipment wear out than to include it in a schedule of routine inspection and maintenance.

In an oil refinery the scheduling of process-unit shutdowns would appear to be a *must* in a preventive maintenance program, in order to prevent failure and loss of production. On the other hand, studies may indicate that operating a processing facility under certain conditions may increase overall revenue, even if it results in intermittent emergency shutdowns. This reasoning has been used in connection with thermal-cracking operations; i.e., by raising the intensity of cracking, the profitability of operations is increased by the additional gasoline yield, even if it results in the unpredicted coking of furnaces and unscheduled emergency shutdowns.

Accounting System—A preventive maintenance program requires an adequate accounting system which will render current returns on the cost of administering the program and on the cost of maintaining each piece of equipment included in it.

Inventory or equipment code numbers are provided for identifying and recording the cost of maintaining each piece of equipment, either manually or through the use of tabulating machines.

All charges for work performed on any piece of equipment included in the program through the medium of any type of work order or job order are collected against the equipment code numbers and recorded periodically on the maintenance-record card. This requires that each work order or job order be written so as to include the equipment code number.

Maintenance Organization and Procedures—When all of the preliminary work in connection with setting up records and establishing the extent of the preventive maintenance program has been performed, the next step is to set up a maintenance-control system embracing:

- An organization which provides for the planning and scheduling of inspection and maintenance.
- Procedures for having the inspection and maintenance work performed.

The organization provides for the functions of inspection, planning and scheduling, and field execution.

The inspection branch of the organization sets up inspection schedules and check lists based on such factors as safety-code requirements, local standards, allowable tolerances, and test results.

The planning and scheduling branch is separate from both inspection and field execution. It operates under a formal written-work-order system. All work to be performed is authorized through the medium of written job orders which are planned in detail and then scheduled through a planning and scheduling system.

Routine inspection and maintenance may be authorized, planned, and scheduled by means of what are termed "standing work orders," effective for a definite period of time—three months, six months, or a year. They are supported by written schedules and check lists. Overhauls are provided for on a definite schedule. Work orders for work to be performed on an overhaul are authorized well in advance, are supported by itemized

work lists, and are planned in detail with respect to men and material.

The proper functioning of a planning and scheduling system is primarily contingent on the authorization of work through the medium of written work orders. Emergencies may be handled by verbal requests, but should subsequently be supported by written orders, and each emergency order should be clearly identified as such for later review. A preventive maintenance program is intended to reduce emergencies to a minimum.

Field execution includes the proper organization of the field maintenance force to perform the authorized work. It provides for the necessary quantity and quality of field supervision; for adequate skilled, semiskilled, and unskilled labor; for the satisfactory division of labor; and for the proper tools and equipment.

Reports—Cost and activity reports are issued periodically for the review of all concerned. Only those reports which are used by responsible supervisors should be prepared, and they should be brief, clear, and current.

The equipment-data card, with its accompanying maintenance-record card mentioned previously, is one currently maintained report which is of great value in keeping track of the preventive maintenance program.

Types of cost reports having value in currently appraising the program include the following: budgeted vs. actual maintenance costs for the plant and for each facility or cost center; estimated vs. actual costs for maintenance and inspection on standing work orders, and on individual maintenance work orders, including overhauls.

Activity reports include periodic inspection reports on the physical condition of equipment, with recommendations as to what action should be taken. Such a report follows each process-unit shutdown and forms the basis for planning maintenance work to be performed on succeeding shutdowns. Similar reports follow the overhaul of a major piece of equipment, such as compressors, turbines, pumps, motors, etc.

Check-off lists for routine scheduled inspections include remarks about the condition of equipment. Intermittent inspection reports follow specific requests for investigating the physical condition of equipment not included in an inspection schedule, e.g., buried and above-ground piping, tanks, insulation, electric conduits, fences, wharves, roads, and the like.

Quality of Personnel—The increasing complication of processes and equipment is resulting in the requirement for more and more specialized knowledge in both operations and maintenance. A training program for both supervisory and non-supervisory employees is, therefore, essential.

A preventive maintenance program should include trained supervisors, inspectors, engineers, and mechanics.

Inspectors may or may not be technical men, but they certainly should have had abundant field experience and should be trained in being objective and accurate in their observations and in the art of writing factual and concise reports. They should know the design and the functions of the equipment which they are assigned to inspect.

The engineer, the man trained in the "scientific approach," is an essential element in setting up and administering a preventive maintenance program. After the studies are conducted, schedules made, and written procedures established, the record keeping may be turned over to the clerical force, the inspection to the inspectors, and the maintenance to the mechanics.

The engineer is needed for such activities as setting up the system of record keeping; establishing inspection and lubrication schedules; determining the critical equipment and spare parts to be carried; formulating a satisfactory planning and scheduling system, with the written work order as its basis; developing an inventory-control system; writing procedures; appraising performance with respect to design; diagnosing equipment failures; studying job methods; assisting in a standardization program; and reviewing material-handling methods and equipment.

Avon's Preventive Maintenance Program—The following paragraphs indicate how much of the over-all scope of preventive maintenance, previously described, the Avon refinery has adopted, and how it is administered.

Plant Inspection—First, the Avon refinery has an independent plant-inspection group. It has two main functions:

- The nondestructive inspection of existing static structures for conformance to safety-code requirements, for evidences of corrosion or erosion, for indications of fatigue, and for general physical condition.

- The inspection of new installations for adherence to design standards and specifications.

Extensive use is made of approved techniques and tools, of inspection, including visual inspection, mechanical calibration, pressure tests, corrosion buttons, trepanning, safety drilling, X-ray and supersonic instruments, fluorescent penetrant inspection, vacuum-seam testing, magnetic-particle inspection, and pipeline-leak detectors.

This group keeps written records of measurements and conditions found in connection with scheduled and unscheduled inspections made on pipelines, furnaces, towers, vessels, tanks, wharves, buildings, fences, power and lighting pole structures, condenser boxes, cooling towers, and heat exchangers. It maintains schedules of required inspections of pressure vessels to be made in accordance with safety codes.

During a process-unit shutdown it inspects all portions of the facility made available by the operating personnel. Complete records are kept of such inspections, and recommendations are made for further inspections and for repairs to be made on succeeding shutdowns.

Inspections of other facilities, reports and recommendations are also made in connection with:

1. Inspection schedules (pressure vessels, for example)
2. Specific requests (buildings, fences, pole structures, wharves)

3. Accident or equipment failures (pipe line breaks, wharf damage, vehicle accidents, tank leaks)

4. Routine operations (changing services of tanks)

Process-Unit Shutdown Scheduling—Process-unit shutdowns are scheduled for 12 months in advance and are revised periodically. These schedules are made up for all major process units; they provide for optimum lengths of run based on conditions reported by the plant-inspection group, on production commitments, and on the desirability of maintaining a reasonably steady work load for the maintenance and construction department.

Rotating Machinery—Except Electrical—The portion of the Avon program pertaining to pumps, turbines, gas engines, blowers, fans, and compressors is administered by a machinery inspector assigned to the project-planning group of the maintenance and construction department. A study was made of this equipment, in cooperation with operating personnel and the mechanical crafts; critical items of equipment were determined; a system of equipment-record cards was set up; written maintenance procedures were issued; and schedules were established for inspection, routine maintenance, and overhauls.

The machinery inspector plans, in detail, the overhaul of the larger equipment, such as gas engines and compressors, and acts as trouble shooter on maintenance and operating problems involving the equipment under his inspection jurisdiction.

He diagnoses equipment failures and makes reports and recommendations for corrective measures, replacements, changes in operating and maintenance procedures, and alterations in design. He assists with the standardization program involving the selection of equipment and interchangeability of parts.

The schedules for routine daily, weekly, and monthly inspections and for minor maintenance work are carried out by the small group of mechanics, assigned permanently to the three maintenance zones, who report results on written check-off lists. Repairs performed on overhauls are also reported by the mechanics performing the work on written check-off lists.

These check-off lists are forwarded to the machinery inspector; he has the pertinent information recorded by a clerk on equipment-record cards which are kept in the central planning office.

Electrical Equipment—Preventive maintenance for motors and other electrical equipment has been developed by the general foreman of the electric shop and is administered by him in conjunction with certain planning functions of the Maintenance and Construction department.

Equipment records for motors, starters, and controllers are maintained by a clerk in the electric shop.

Motor servicing is handled through a "tickler" file system maintained in each of the three zone offices. At the beginning of each year a job order is issued by the electric shop to each of the zone offices for the servicing of motors in the zone. A schedule, listing by weeks the motors which are to be serviced in the zone during the year, is attached to each job order.

The clerk in the zone office, through the medium of his "tickler" file, advises the zone planner each week of the motors which are to be serviced the following week. It is then the responsibility of the zone planner to provide, on the daily work schedule during the following week, the manpower to complete the servicing of motors specified for that week on the annual motor-servicing schedule.

The record of motor servicing performed is entered on a card by the mechanic who did the work and is forwarded to the electric shop for transfer to the permanent equipment records.

Motor-bearing oiling is performed on a weekly schedule by one mechanic from the electric shop.

Other items of electrical equipment inspected and maintained by electric-shop personnel on the basis of established schedules are: diesel-electric locomotives, fork-lift trucks, synchronous motors, and the Cottrell precipitator.

Servicing of elevators is performed on a preventive maintenance schedule by an outside contractor specializing in this type of operation.

Checking for grounded circuits is performed on a routine schedule by electricians on the afternoon and graveyard shifts.

Instruments and Controls—Preventive maintenance on instruments and controls is administered by the instrument shop. The Avon refinery policy has been to concentrate responsibility for the inspection and maintenance of all instruments and controls in one craft, whether they are mechanically, electrically, or electronically operated.

Equipment records are being kept on relief and control valves. The valves are serviced, where possible, on schedules accompanied by check-off lists. Attempt is made to check and test all relief valves once a year. Records have been set up for relief valves, reflecting details of design, metallurgy, and spare parts. Where maintenance costs appear excessive on the record cards, investigation is conducted as to the desirability of changes in selection, design, or metallurgy.

Servicing of indicating gages, thermometers, pyrometers, meters, controllers, transmitters, and vapor-recovery equipment is conducted in the field through the medium of blanket job orders for a definite period of time, supported where possible by written schedules and check-off lists.

Planning and Scheduling—The Avon refinery has a formal planning and scheduling system based upon the following general principles:

1. Planning is separated from field execution.

2. Work is authorized through the medium of individual job orders written by operating or facility supervisors to three zone offices, for jobs whose aggregate cost is estimated to be less than $1,000; or to a project planning office, for jobs costing $1,000 or more.

3. Each job order is planned and estimated to the nearest hour by a planner, in terms of: *a*, man-hours by crafts; *b*, craft sequence; *c*, material required; *d*, priority; *e*, date available; *f*, date to be planned; *g*, date

API Maintenance Session

to be completed; *h*, scope of the work, with drawings and sketches attached; and, *i*, safety and fire-prevention measures to be taken.

4. Priorities are of three classes: *a*, emergency; *b*, priority No. 1; and *c*, priority No. 2. Emergency jobs are those which cannot wait for formal planning procedures and which cause an interruption in the work as planned. Priority No. 1 jobs are those formally planned, which are to be completed by the date listed on the job order. Priority No. 2 jobs are also formally planned, but permit completion dates to be arranged on the basis of available manpower or material and prior work commitments.

5. Blanket job orders, issued for a definite period of time to make a preventive maintenance program effective, are supported by written schedules and check-off lists wherever possible.

6. Manpower required is balanced daily against manpower available in the various crafts.

7. A written daily work schedule is issued to the entire maintenance and construction department for work to be performed on the following day. This schedule lists all current jobs by zones and by crafts, with the estimated number of men and hours required for each job.

8. The daily balancing of manpower and preparation of a daily work schedule is performed in a central planning office which is the heart of the entire planning and scheduling system.

9. A weekly project work schedule is issued by a project-planning office on Thursday of each week, for the major maintenance and construction projects, including process-unit shutdowns, to be performed during the following week. This schedule serves as a target for the central planning office, which does the daily scheduling of all work, in dovetailing the project jobs with the zone maintenance jobs.

10. Process-unit shutdowns are planned three to four weeks in advance of the shutdown, except in the case of the fluid catalytic cracker where planning starts at least six months ahead.

11. An attempt is made to keep emergency jobs to a minimum. In terms of job orders, the target for the maximum number of emergencies is on the order of 10 per cent. This represents about 3 per cent of the total man-hours.

Personnel—The Avon refinery does have a training program for the training of mechanics, inspectors, and operators. Jointly administered by management and the union, it has been included in the labor agreement for the past 12 years. Both parties may be justly proud of the manner in which the program has functioned over this period of time.

Assigning of engineers to the maintenance ranks for field training has been inaugurated during recent years. Maintenance functions having to do with such activities as inspection, planning, scheduling, methods improvement, and material handling are being examined more and more in terms of what the engineer can do to set up and administer a program in which they are included.

The Future—There is, of course, much more to be done at Avon before approaching or achieving the complete program. A large part of it is, however, on the way.

Business-machine accounting is soon to be applied to inventory control. It is anticipated that the existing application of mechanization to maintenance accounting will be widely extended and will assist considerably in the further development of the preventive maintenance program in particular and maintenance activities in general.

Many studies are being conducted for such purposes as: improving the present organization and procedures, establishing a complete list of critical equipment and spare parts, developing more extensive schedules, setting up an adequate record-keeping system, and providing for the proper number and kinds of management-control reports.

The Avon refinery is engaged in an extensive expansion program. Provision for preventive maintenance is an essential part of that program and is being developed concurrently with the construction of new facilities.

This paper originally presented before API Division of Refining Meeting, Montreal, May 15, 1956.

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Meet the Author

CREIGHTON C. CARMINE was graduated from the Naval Academy at Annapolis in 1918 and took his master's degree in mathematical physics in 1925. His association with the oil industry dates from 1928 when he joined Associated Oil Company, later merged into Tide Water Associated Oil Company. During World War II he served in the Navy as a machinery- and electrical-inspection officer and later as supervisor of shipbuilding at San Francisco and New York. After the war he served as mechanical superintendent in charge of field maintenance and construction at Tide Water Associated Oil Company's Avon refinery. He was named to his present position as supervisor of maintenance and construction at Avon in 1951.

Maintenance Session

How to Measure Maintenance Results

These methods enable you to measure results by comparing costs with replacement value of the equipment maintained.

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The Standard Oil Company (Ohio), Cleveland

REFINERY MANAGEMENT needs to know where it stands on maintenance. This need involves both the cost of maintenance and the result of maintenance activity.

Among the several methods of comparing maintenance costs, the most useful method found to date is the ratio of maintenance costs to replacement value of the equipment. Factors which influence variation in these ratios are:

- Differences in level of operation
- Type of process
- Soundness of design
- Organization and skill of the mechanical and operating functions

Maintenance is hard to get a handle on. Made up, as it is, of an ever-changing procession of individual jobs, maintenance is elusive and difficult to measure in general terms, and much too complicated to handle in detail.

One Point of View—There are many ways of looking at maintenance, each way suited to some specific purpose.

One point of view is that of refinery management, measuring what is seen in terms significant to the conduct of refining as a business. This might be the point of view of a plant manager attempting to assess the results of his total maintenance function; or a maintenance superintendent—trying to guide the specific efforts of his own group by the over-all effect that maintenance has on total refinery costs.

Definition of Maintenance—What is maintenance? There are many slightly different concepts. It is perhaps agreed that repairing or replacing parts of a facility in order to restore it as originally built is maintenance. Many also include equivalent replacement. Mechanical work done to permit engineering inspection would probably be allowed by most. Cleaning is usually included in "maintenance," although cleaning involving product recovery, such as coke-drum cleaning or press shaking, is usually not included.

Many minor improvements and relocations are accomplished along with necessary repairs. Some call this maintenance; some do not. A few even include minor capital work, designed to maintain the *relative* efficiency or usefulness of the facility, in maintenance.

This look at "maintenance," includes all labor and material of mechanical crafts, including common labor, within limits of Federal income tax regulations on expense. This is a broad use of the term, leaving out only capitalized improvements.

This has been done for two reasons:

1. There is considerable overlap among the various categories of mechanical work mentioned. It is difficult to obtain any consistent breakdown of such work, even within a single plant.

2. From the over-all point of view, the effect of the work done is not changed by subdividing it. (Note that the advantage of classifying work for maintenance management is not disputed. It is merely proposed not to discuss that subject in this article.)

All comparisons presented here are on this more inclusive basis. Please note that this is the *direct cost of maintenance.* It does not include maintenance services, such as trucking, or operating the warehouse, or the shops. Nor does it include maintenance supervision, planning, engineering and general administrative expense. Maintenance—payroll—burden expense is not allocated in most data and is not included here. Taken altogether, these indirect charges may aggregate 40 to 60 percent of the direct maintenance costs. You may apply such a percentage to these figures as a means for estimating the total maintenance cost of the examples presented.

Indirect Effects of Maintenance—Maintenance has a double effect on refining. One effect is the physical effect upon the *life,* the operating *continuity,* and the *efficiency* of operating facilities.

This physical effect has financial aspects of its own. They turn up in the form of yields and processing costs, inventory carrying charges and opportunities for profitable sales.

The second effect on refining is the direct cost of maintenance. Examining this cost of maintenance is the main subject of this article and will be dealt with first. Later the physical effects of maintenance will be discussed. The cost aspect involved in physical effects are indirect, but may be even greater in magnitude than the direct costs.

Maintenance Cost as a Function of Production—Maintenance is often related to production in terms of cents per barrel of crude. This number is easy to obtain for most operations. The values are simple numbers in the order of 10 to 25 cents, hence are easy to remember and compare.

Figure 1 shows some data collected recently on direct maintenance cost expressed in terms of cents per barrel of crude for some complete refineries.

Notice the wide variation which appears here. The higher values are almost three times the lower. These

How To Measure Maintenance Results . . .

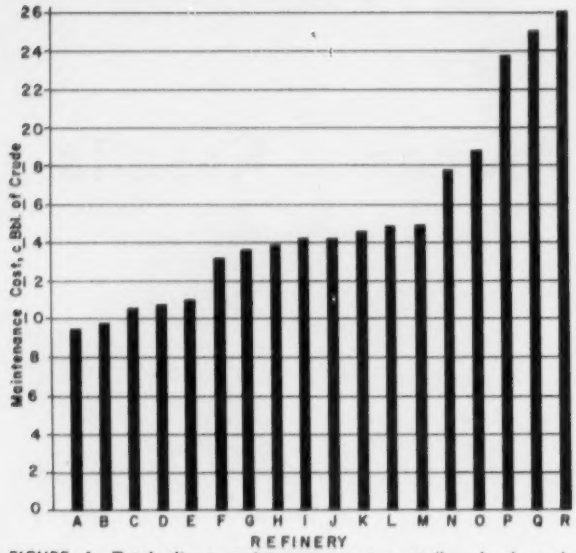


FIGURE 1—Total direct maintenance cost cents/barrel of crude throughput.

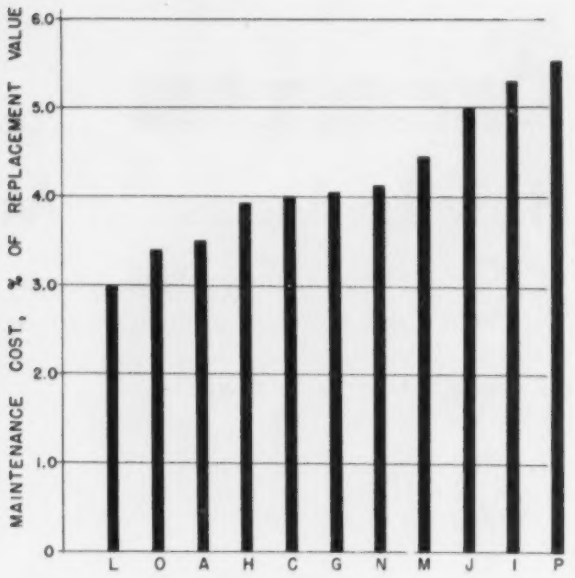


FIGURE 2—Total direct maintenance cost as percent of refinery replacement value.

plants are fairly similar; all are complete gasoline refineries. Purchasing value of the dollar is not a variable here since these calculations are all for the same period. There is no correlation with size of plant. This is not a difference in maintenance standard, since some of the better maintained plants may be found at opposite ends of the scale. Neither can location, weather, labor rate, nor age be used to explain these differences.

These observations prompt the belief that differences in crude source, plant facilities, and product demand make crude rate a poor basis for maintenance comparison.

Enlarging upon this, some crudes are much more corrosive than others. The secondary operations of a plant, such as solvent lube extraction and alkylation, involve greater maintenance problems than do simple topping operations at the same crude rate. A plant producing a wide variety of high-value products involves more processing and hence more maintenance. It is not reasonable to expect maintenance cost per barrel of crude to be constant, even at equal efficiencies.

In January of this year the editors of PETROLEUM REFINER[4] published the results of an industry-wide survey which related maintenance cost to product value. Their survey showed an average maintenance cost of 3.4 percent of product value, approximately 2.2 percent labor and 1.2 percent material.

In the same manner, maintenance expense may be related to total refinery operating expense, or to value added in refining. In some industries it is related to the amount of power consumed, or expressed as a ratio of maintenance labor to production labor.

All of these approaches are attempts to evaluate maintenance in terms of the amount of production or thruput. Some of this information, bordering on the confidential, is hard to obtain for comparisons outside of one's own organization. Other comparisons, particularly of product values, may vary widely by location and time, without any corresponding variation in maintenance.

Maintenance Expressed as Total Dollars—Difficulties in arriving at a maintenance ratio or index have caused some to drop the idea of making maintenance comparisons with other operations, and to concentrate on reducing the dollar amount of their own maintenance expenses.

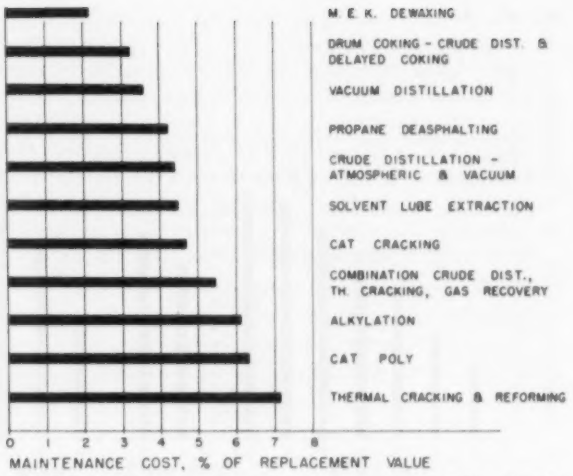
A recent expression along these lines by R. I. Reul[5] advocated working against a plant's own record. This approach is certainly useful in controlling the maintenance of a specific plant. However, it does not provide any method for distinguishing between historically good experience and situations where maintenance costs have been high from the beginning. Something more absolute is needed for management evaluation of the maintenance function.

Counting Equipment to Evaluate Maintenance—Because of the difficulties mentioned previously, some better basis has been sought for examining maintenance costs. M. A. Pappas,[2] reporting to the Division of Refining Meeting, Houston, in May, 1954, showed that while process results were similar, in two plants, the number of pieces of equipment installed in one plant was larger than in the other, and the maintenance in that plant was proportionately greater.

This may be a logical observation. To a considerable extent, maintenance is a replacement of parts, and the more parts, the more replacement. Other maintenance functions, such as cleaning, inspection, etc., are also directly related to number of parts.

This approach is quite sound, but it may be difficult to apply, particularly in general management reviews. Certainly, the size of a part makes some difference in maintenance cost. Furthermore, it is difficult to add up valves and pumps and structural steel into total units of maintenance. The number of pieces is difficult to count and almost impossible to weigh and summarize for complete production units and refineries.

Maintenance Ratio to Investment—R. M. Cziner[3]


M. E. K. DEWAXING
DRUM COKING - CRUDE DIST. & DELAYED COKING
VACUUM DISTILLATION
PROPANE DEASPHALTING
CRUDE DISTILLATION - ATMOSPHERIC & VACUUM
SOLVENT LUBE EXTRACTION
CAT CRACKING
COMBINATION CRUDE DIST., TH. CRACKING, GAS RECOVERY
ALKYLATION
CAT POLY
THERMAL CRACKING & REFORMING
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MAINTENANCE COST, % OF REPLACEMENT VALUE

FIGURE 3—Maintenance cost on major process units in Sohio refineries showing life averages.

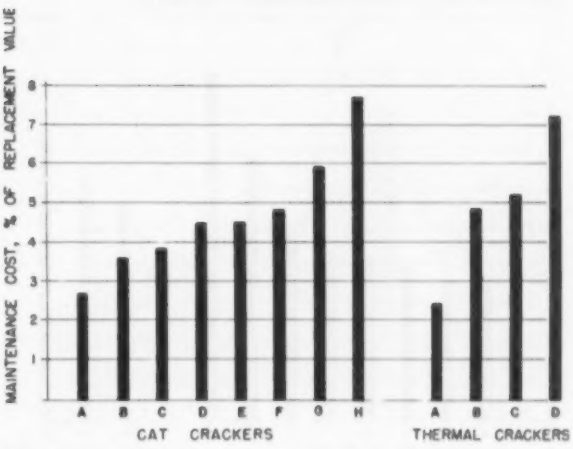

FIGURE 4—Maintenance cost for cat crackers and thermal crackers in Sohio refineries and others.

TABLE 1

Division of Equipment Into Major Gasoline Refining and "Other" Eight-Refinery Average

	Major Gasoline Refining Equipment	Other Equipment	Total Equipment
Percent of total maintenance cost	47	53	100
Percent of total refinery replacement value	45	55	100
Maintenance cost, percent of replacement value	4.1	3.7	3.9

TABLE 2

Division of Equipment Into Major Gasoline Refining and "Other" Individual Refineries

	MAJOR GASOLINE REFINING EQUIPMENT		OTHER EQUIPMENT		TOTAL EQUIPMENT
REFINERY	Percent of Total Equipment	Maintenance Cost, Percent of Replacement Value	Percent of Total Equipment	Maintenance Cost, Percent of Replacement Value	Maintenance Cost, Percent of Replacement Value
A	38	3.71	62	2.54	2.98
B	36	4.91	64	2.59	3.42
C	66	3.48	34	4.78	3.93
D	55	4.20	45	3.80	4.02
E	45	3.38	55	4.57	4.03
F	40	6.07	60	2.77	4.10
G	51	4.55	49	5.39	4.96
H	46	4.06	54	6.28	5.27

expressed annual maintenance ratios as 2 to 10 percent of investment for various classes of equipment. F. C. King, Jr.,[1] used the same basis for comparing maintenance labor, and added a corrective feature for changes in building costs to take out the variable of inflation.

The thinking expressed by these authors appeared to support the following premises:

1. The largest factor in determining maintenance expense is the amount of facilities installed.
2. Investment cost is a good measure of facilities installed, if corrected for inflation in labor and material unit costs.

To these premises we have added—

3. Total direct maintenance cost is more significant than the labor component alone.

In arriving at the third premise, it was observed that the use of contractor maintenance forces and the fabrication of repair parts within the refinery are two practices which varied greatly from plant to plant. These are presumably decided on the basis of local conditions. They materially affect the direct labor component of maintenance, the first downward, the second upward. The real objective of these practices is to minimize total cost of maintenance, and we have directed our attention to the latter.

There are many other variables which affect maintenance beside investment. And some investment obviously affects maintenance inversely. One example is alloy pipe in place of carbon-steel pipe; another—useful built-in mechanical-handling facilities. These installations raise investment, but reduce maintenance.

We may better judge the magnitude of these contrary effects by looking at some specific examples.

Maintenance Ratios for Refineries—Wherever enough data was available, the ratio of current direct maintenance expense to replacement cost is calculated for the refineries used in Figure 1. These ratios are shown in Figure 2.

Notice the reduced range among the various plants shown. Compared to a three-to-one range in the cents-per-barrel illustration, the range among these data is less than two to one.

Notice that the refineries do not line up in the same order as in the Figure 1, where the plants were arranged alphabetically in the order of rising maintenance cost. This suggests a more realistic maintenance cost comparison by reducing the factor of size and complexity.

We must admit that there is still a good deal of variation. There must be reasons behind these differences. These reasons could involve different basic design standards, different process severities, different maintenance

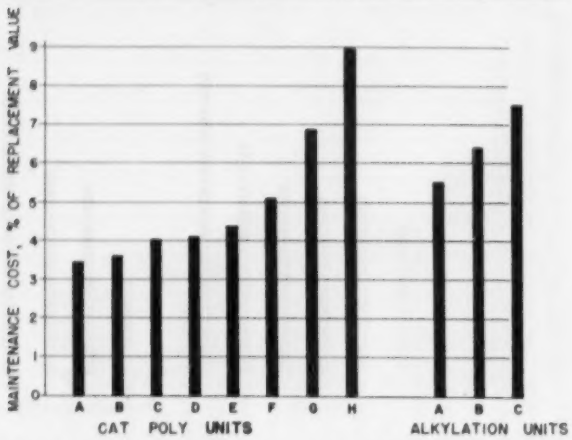

FIGURE 5—Maintenance costs for cat poly units and alkylation units in Sohio refineries and others.

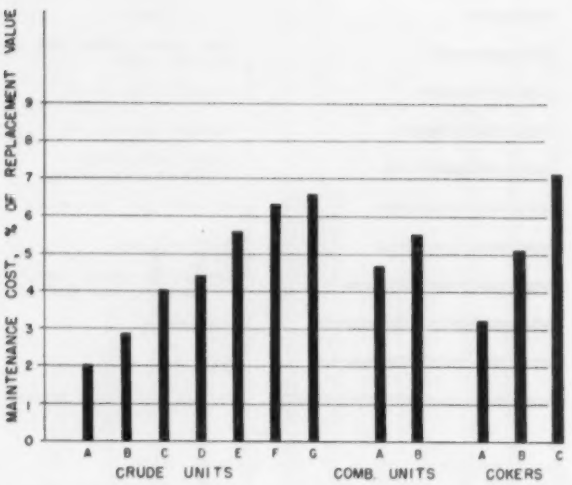

FIGURE 6—Maintenance costs for crude units, combination units and cokers in Sohio refineries and others.

efficiencies, or other basic differences. Perhaps these reasons are controllable—perhaps not.

Breaking these data down, we may get leads to these reasons.

For eight of the refineries tabulated in Figures 1 and 2, there was enough data to split out major gasoline-producing units from other refinery facilities. This split is summarized in Table 1.

The major gasoline-refining units involved slightly less than half of the plant investment, and required less than half the plant maintenance. The maintenance ratio for "other facilities," on the average, is only slightly lower than the ratio for major refining units.

A closer look at these same eight refineries Table 2 presents plant-by-plant the same data summarized in Table 1.

Except for one plant, major units as a group do not differ too greatly from plant to plant, but "other facilities" show greater variation.

From these data one might surmise that maintenance expenditure on "other facilities" may be the major variable in total refinery-maintenance costs.

How do the various producing units compare on maintenance ratios? Here Sohio data alone has been drawn upon for the values shown in Figure 3. These data are lifetime averages for each process.

There is quite a difference between the various processes. In general, one might conclude that the processes involving higher temperature, higher pressure, or corrosive material will have higher maintenance ratios. This is quite reasonable, although the magnitude might not have been predicted.

Figure 4 illustrates maintenance costs on a number of cracking units. These are data for single years in most cases.

Of the eight cat-cracking units shown, the two on the right are abnormal. The highest, a new small unit, experienced an operating upset which seriously damaged the unit during the year reported. The other is an older unit, which has since been replaced.

Among the thermal-cracking units there is quite a substantial variation. The average ratio, however, is not far different from the catalytic-cracking-unit ratio. This is unlike the Sohio experience shown on the preceding chart.

The same type of information is charted for cat poly and alkylation units in Figure 5.

With the exception of two poly units, where acid carryover has been a major problem, these experiences have been uniform within their respective groups.

There are also some significant data on crude processing facilities. These are exhibited in Figure 6.

There is more variation than we expected in regular crude distillation equipment. It may be significant that the three highest units are all older ones. The two com-

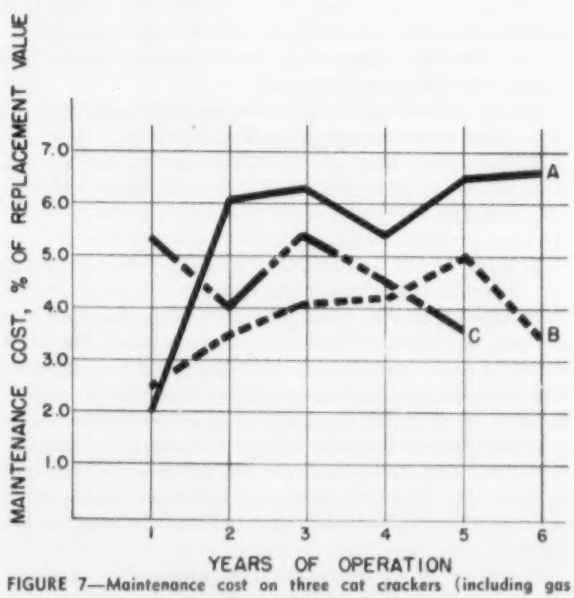

FIGURE 7—Maintenance cost on three cat crackers (including gas plants) of different types.

bination units line up fairly well with their crude and cracking components. The three coking units are quite variable. Perhaps the one on the right should be discounted because of a questionable replacement value.

The apparent effect of age on maintenance ratios suggests another approach to their use. The life histories of some units have been plotted in terms of maintenance ratios. In these plots, as in the life-average data presented earlier, the maintenance cost for each year is divided by the replacement value for that same year.

Figure 7 shows life history data for three catalytic-cracking units. *A* is an older unit which was rebuilt after the six-year period shown. *B* and *C* are different catalytic-cracking processes currently operating on similar feed stocks.

Figure 8 presents the 25-year life history of four thermal-cracking and reforming units. (Data from the first two or three years of operation are missing.)

Maintenance was fairly normal until 1945. During

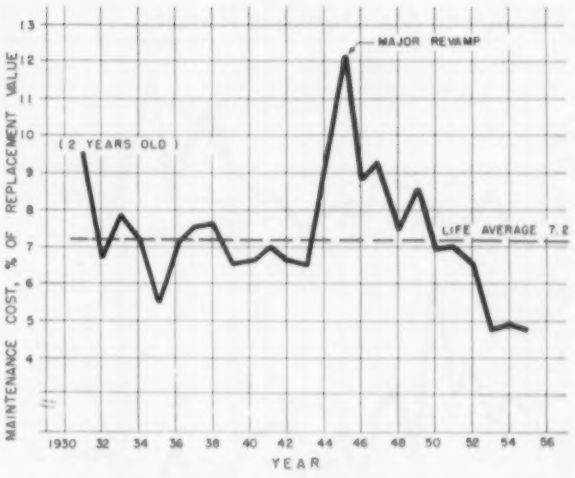

FIGURE 8—Maintenance cost on four thermal cracking and reforming coils.

FIGURE 9—Maintenance cost on an alkylation unit.

World War II, drastic cracking for codimer feed and deferred maintenance led to major repair work.

As these units approach the end of their useful life, maintenance is being held to the minimum required for safety. Note how the curve highlights these effects.

The maintenance data of Figure 9 are presented largely as a matter of curiosity. Under wartime pressures, this baby alkylation plant was revamped 18 times to attain a tenfold increase in capacity. The periods of high maintenance coincide with peak-production periods when military demand was greatest.

Table 3 shows some random data from two of the company's refineries. Note that pumps have a relatively high average-maintenance ratio of 7.0, and a wide range of individual results. Cost ratios for motors averaged much

API Maintenance Session

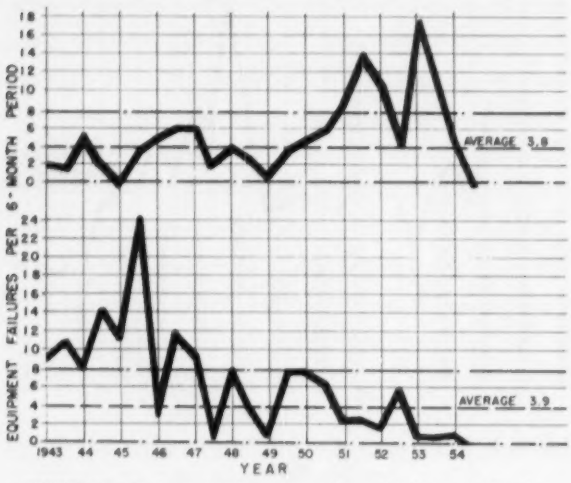

FIGURE 10—Equipment failure on major units in two refineries.

lower, 1.2 percent, but still exhibited a fairly wide range. Classifications such as these cover a wide range of services. By comparing maintenance ratios for equipment in similar service, good and bad units can be readily identified.

TABLE 3
Maintenance Cost on Two Classes of Equipment
(Each Class Sampled From One Refinery)

	Percent of Replacement Value	
	Average	Range
Pumps	7.0	1–18
Electric Motors (1-100 HP)	1.2	0.1–5.1

Maintenance ratios based upon capital-replacement values bring some semblance of order to maintenance comparisons. While such comparisons are not exact, they may help to find areas of possible improvement and point the way for engineering and administrative attention.

Physical Effect of Maintenance—What is bought with the direct cost of maintenance?

- Safe operation—no accidents, few equipment failures.
- Efficient performance—low operating cost—high yield.
- Continuity of operation—production when we want it.
- Quality—control over the quality of the products which we make.
- Optimum life for our capital investment.

How do we know we are getting what we pay for? How do we measure the physical results of our maintenance?

1. Observation and Inspection—The experienced observer can form some judgment of maintenance result. General housekeeping will correlate to some degree. Presence or absence of signs of minor deterioration may give a lead. Eroded ground surfaces, scaling paint, crumbling insulation, leaking packing, and scattered debris are some of the witnesses to declining-maintenance situations which give warning before major failures occur. However, this warning is not too reliable and can lead to favoring small maintenance over larger and more important maintenance.

The observations and records of engineering inspection provide a more quantitative appraisal of maintenance results. Inspection can exercise control on *under*maintenance, but does not measure *over*maintenance as readily.

Service factors are often used as a measure of maintenance effectiveness. These factors are calculated in several different ways, and are influenced greatly by the way the units are operated. This control has a tendency to motivate operators to extend runs rather than maximize production. For this reason, it may prove disadvantageous to use it as a measure of performance.

2. Failure-Rate Analysis—Serious maintenance weaknesses will show up in a bad accident record, but even plants with good maintenance have some failures. We are attempting to study such failure records statistically without regard for the specific causes.

Figure 10 presents a chronological plot of equipment failures in two refineries over a considerable period of time. The failures reported included such things as furnace-tube splits, exchanger difficulties, blown-out pump packing, seized bearings, line breaks, etc. About 80 percent of these failures resulted in unit shutdowns, at least temporarily. One point appears on the chart for each 6-months period over the past 10 to 12 years.

Each of these plants experienced a long period of relatively low failure. But both plants went through a period of significantly higher failure rates.

Incidentally, the average failure data for the better periods on these charts compare quite closely to similar experiences in other plants with low failure rates.

This same type of information is shown in Figures 11 and 12. These are frequency-distribution charts, in which the number of unit time periods having a given failure rate is plotted against the number of failures per period.

Figure 11 presents combined data from six major units in another refinery.

The shape of the chart looked very much like a Poisson distribution, and a calculated Poisson curve was superimposed on the chart for comparison.

What does this mean? As yet nothing has been proved. It suggests some interesting possibilities. Failure-frequency charts might help distinguish good over-all refinery performance from erratic or generally poor performance.

Another frequency distribution chart is presented as Figure 12. This is the same data as plotted in the upper curve in Figure 10. The performance in this plant is not nearly as consistent with the Poisson distribution as Figure 11. The chronological plot in Figure 10 included one, 3-year period of higher failure frequency. What is seen here is the effect of that period on the distribution.

These data, while dealing with mechanical failures, reflect the combined activities of the operating and the mechanical forces. The skill and effectiveness of the operating personnel may be a greater factor in maintenance cost than that of the maintenance people. Work is under way on separating the basic causes of maintenance work, but there have been no significant results to date.

These different appraisals all help. Observation, engineering inspection, accident records, and statistical analysis of failures, all contribute to better understanding of maintenance result. But they do not seem to fill the bill completely. Some way is still needed to add up the effort of maintenance as a whole.

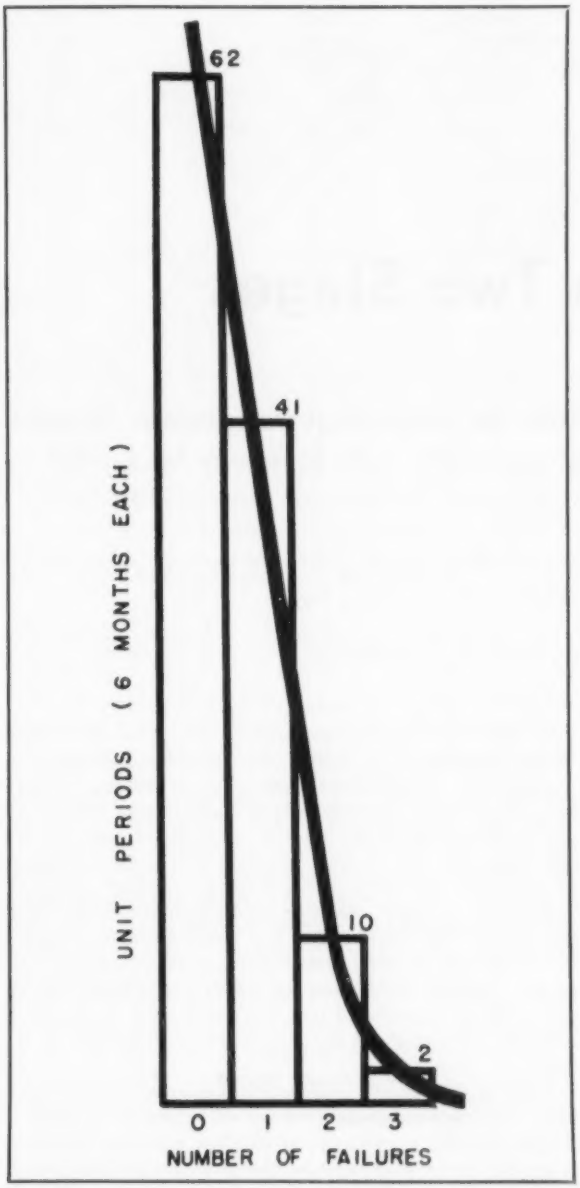

FIGURE 11—Frequency distribution of failures on major units at a refinery over a ten-year period (20 six-month periods × 6 units = 120 unit periods.) Average number of failures per unit per six months = 0.58.

Maintenance is a long-term activity and some of its results are slow to show up. Whether the problem is to bring down maintenance cost without unduly risking the operation, or whether it is to raise the quality of maintenance without incurring excessive costs—management still needs sensitive over-all indicators to show results of maintenance activity covering entire processes and complete refineries.

In the area of maintenance result, the need remains for over-all measures of effectiveness. True long-term optimum maintenance costs will be accomplished only when effective controls are developed for current maintenance in terms of its total effect. If this article can stimulate some further thinking and publication in the area of maintenance result, it will have served its purpose.

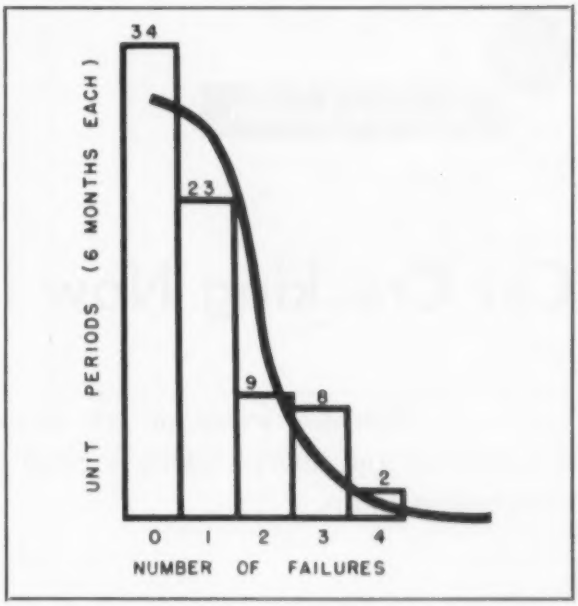

FIGURE 12—Frequency distribution of failures on major units at a refinery over a ten-year period. (20 six-month periods × 4 units = 80 unit periods). Average number of failures per unit per six months = 0.96.

Original presentation was before the API Division of Refining Meeting, Montreal, May 16, 1956.

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Meet the Author

EDWARD S. BALE, who presented this paper, was graduated in 1934 from Case Institute of Technology with a degree in chemical engineering. That year he joined Standard Oil Company (New Jersey) as a process engineer, a position he held until 1939. From 1939 to 1944 he was process engineer for The Standard Oil Company (Ohio). Since then he has served that company in various capacities. In 1944 he became refinery superintendent and in 1949, was promoted to refinery manager. In 1952 he became chief of the Manufacturing department's Operations staff—the position he now holds.

API Maintenance Session

Process Session

Cat Cracking Now in Two Stages

This new technique gets away from the single-stage compromise between overcracking and undercracking a given feed stock. The technique may be applied to some existing units.

J. D. Heldman, F. Kunreuther, J. A. Marshall and C. A. Rehbein,
Shell Oil Company

WHEN A FEED having a wide boiling range is cracked, a compromise severity is required at which the least refractory components are cracked too severely and yield large amounts of gas and coke while other, more refractory components undergo only low conversion. The wide distribution of vapor residence times in the fluid beds of conventional catalytic cracking units aggravates the overcracking/undercracking losses.

To minimize these losses, uniform oil/catalyst-contact-time is desirable. Moreover this contact time should be short to avoid secondary reactions of the gasoline produced from the least refractory feed components. Under such conditions high-temperature operation is desirable since the coke reduction obtained is not accompanied by the usual loss in gasoline yield ascribed to secondary reactions. All of these considerations can be met by carrying out the initial cracking step in a short-contact-time riser reactor, operated at high temperature. Further benefits can be gained from use of a second (and possibly more) reaction stage to which unconverted material from the preceding stage is fed.

The Shell two-stage catalytic cracking process was developed to combine the advantages of short-contact-time cracking and of multiple staging. Their use in finished process schemes has required investigation and development of new techniques in almost all phases of fluid catalytic cracking.

The commercial unit which was recently put into operation at the Anacortes, Wash., refinery of Shell Oil Company climaxed several years of intensive research and development. The major portion of the experimental work was carried out by the Houston Manufacturing Research Laboratory of Shell Oil Company.

Two pilot-scale catalytic cracking units were employed in the development of cracking techniques and conditions used in the two-stage process. The first-stage unit, consisting of an upflow riser reactor, a stripper, a regenerator, and product fractionation columns, is capable of continuous operation at thruputs up to eight barrels of feed per day. Second-stage cracking of gas oil from the first stage was accomplished in two dense-bed pilot plants. One of these, which has been described in a previous publication,[12] operates semi-continuously at feed rates up to about one gallon per hour. The other dense-bed unit consisted of a modification of the dispersed-phase cracking pilot plant in which the stripper vessel was used as a dense-bed reactor. The ranges of cracking conditions investigated in most of the work are shown in Table 1.

Most of the pilot plant operation, employing two separate units, was equivalent to parallel flow of catalyst—that is, freshly regenerated catalyst was used in each stage. In other experiments, series flow was employed; i.e., partially spent catalyst from the first stage was used in the second stage.

Several commercial equilibrium catalysts and a wide variety of commercial and experimental feed stocks were used in these studies. However, except where otherwise stated, the results presented in this paper were obtained with West Texas flashed distillate and equilibrium microspheroidal catalyst withdrawn from Shell's Houston refinery. During the pilot plant investigation, several large batches of this catalyst and feed were used. The proper-

TABLE 1
Experimental Cracking Conditions

	First-Stage	Second-Stage
Temp., °F	875 to 1,050	900 to 1,000
Press., psig	16	16
Oil Contact, sec.	2 to 15	10 to 40
Catalyst/oil ratio	3 to 50	2 to 15
Conversion, Vol., %	20 to 70	15 to 70
Total Conversion, Vol., %	50 to 80	

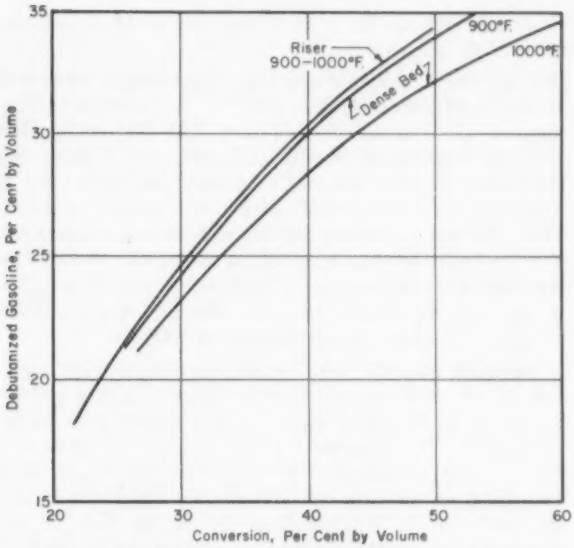

FIGURE 1—The riser gives a more uniform residence and thus produces a higher conversion of the feed to gasoline.

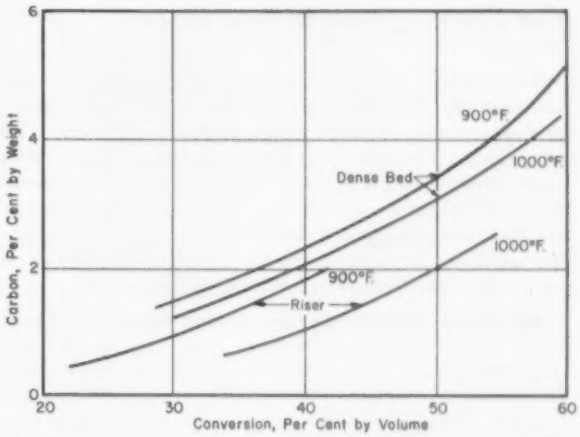

FIGURE 2—There is little destruction of the cracked products so that the coke formation is low.

ties shown in Tables 2 and 3 are typical of the materials employed.

In addition to the development of cracking techniques and conditions used in the two-stage process, the engineering aspects of fluidization, catalyst transport, catalyst-gas separation, stripping, and regeneration were investigated on pilot plant, semicommercial, and commercial scales. These studies, which included the use of radioactive tracers and gamma-ray attenuation, involved detailed evaluations of the performance of six commercial units of varying designs. Stripper performance and the pressure drops and catalyst flow patterns in the standpipes and risers of these units were investigated extensively. A semicommercial stripper and a semicommercial riser capable of transporting one ton of catalyst per minute were operated to develop novel designs and to provide data on stripping and on catalyst flow. These same units and others were also used to obtain data for design of the high-capacity cyclones required for the separation of first-stage products from the catalyst.

TABLE 2
Catalyst Properties
(Commercial Equilibrium Synthetic Silica-Alumina)

Surface area, sq m per g	89
Pore volume, ml per g	0.25
Particle size distribution (by sedimentation), percent by weight:	
<40 microns	6
40 to 50 microns	12
50 to 60 microns	19
60 to 70 microns	18
70 to 80 microns	15
80 to 90 microns	12
90 to 100 microns	9
> 100 microns	9
Contaminants analysis, percent by weight:	
Iron	0.12
Vanadium	0.003
Copper	0.0012
Nickel	0.003
Chromium	0.0041

TABLE 3
West Texas Feed Stock Properties

API gravity	29.1
ASTM Distillation, Degrees Fahrenheit:	
IBP	450
10 percent by volume	540
50 percent by volume	660
Pour point, degrees fahrenheit	+70
Ramsbottom carbon residue, percent by weight	0.15
Sulfur, percent by weight	0.57
Kinematic viscosity at 100 F, cs	13.5

A short-contact-time riser was used for the first-stage reactor. The upflow riser-reactor pilot plant demonstrated the advantages that can be obtained from short-contact-time riser cracking vs. conventional fluid-bed cracking. The superiority of the riser technique is evident from the gasoline and carbon yields shown in Figures 1 and 2, respectively.

The advantage of the riser is magnified at the higher temperature. In riser cracking, the increase in temperature serves to decrease coke production without affecting gasoline yield, whereas an accompanying decrease in gasoline is experienced in dense-bed processing.

The superiority of the riser technique shown in Figures 1 and 2 is the result of three factors: (1) establishment of uniform residence time and reduction of dilution of feed by cracked products due to the concurrent flow of catalyst and oil vapor, (2) better contacting efficiency between catalyst and oil, and (3) higher average catalyst activity. These factors permit operation at high conversions with little destruction of cracked products, thereby resulting in lower coke and higher gasoline yields.

In addition to the foregoing benefits of riser cracking, it was also found that the over-all severity for achieving high conversions (70 percent and higher) could be kept much lower in two-stage cracking. This is the result of processing the more refractory gas oil from first-stage cracking in the absence of the diluent gas and gasoline produced up to the first-stage conversion level.

After the feasibility and superiority of riser cracking had been established in principle, attention was turned to those questions which had to be answered before a successful integrated process design embodying the potential gains could be made.

The effect of temperature variations in the two

reaction stages was given detailed study. From the various possibilities, a higher riser (first-stage) temperature and lower second-stage temperature was chosen. This temperature sequence is obtained commercially with series flow of catalyst from the first to second reactor stage. Pilot-plant experiments in which series flow of catalyst was employed showed that the low level of coke deposited on the catalyst in the first stage has no effect on product distribution in the second stage.

Optimum first-stage conversion level was found to be primarily dependent upon feed stock quality and dependent to a lesser extent on total conversion and temperature sequence. The over-all catalytically cracked gasoline yield obtainable peaks rather sharply at a particular first-stage conversion for any given feed and coke make. The first-stage conversion which leads to a maximum gasoline may not be optimum from an economic standpoint, of course, depending on the downstream processing facilities: for example, polymerization vs. alkylation of olefins, the marketing situation, and other factors. Economic evaluations using typical product values showed that first-stage operation at conversions differing somewhat from optimum does not incur significant economic penalties. This is an important consideration in process flexibility.

Various feed stocks were investigated. Comparisons for some of these feeds are summarized in Table 4. With the West Texas feed, two-stage cracking permits the highest conversion at constant carbon yield; conventional recycle operation gives yields intermediate between those from single-stage and two-stage cracking. Similar results are obtained with other feeds of widely differing quality, as indicated by the single vs. two-stage comparisons for Redwater and Los Angeles Basin flash distillates shown in Table 4.

The differences in the yields of gaseous hydrocarbons are due in part to the cracking temperatures employed in the comparisons and in part to the processing techniques. At constant temperature and conversion, less dry gas is produced in riser cracking than in dense-bed operation, but the trend of increasing gas production as temperature is raised holds with either method of operation. These two factors explain the increased gas make for the two-stage cracking results shown for West Texas and Redwater compared to single-stage cracking at 900 F, and the decreased gas make for Los Angeles Basin compared to single-stage operation at 1000 F.

Product quality from conventional single-stage cracking differs from the present two-stage cracking process primarily in the compositions of the gasolines as shown in Table 5. The properties of the final gas oils produced by the two techniques are essentially the same when compared at constant conversion. The differences which do exist can be explained largely on the basis of the different conversions obtained at a given coke yield.

Despite the large variations in the compositions of the gasolines produced in the various processes, the leaded Research method octane ratings of these gasolines are essentially the same. The calculated Research method +3 cc TEL ratings of the total 10 pound RVP gasolines from all the processes fall in the range 100.0 to 100.5 octane number.

The higher olefin and lower aromatic content of two-stage gasoline result from the fact that a very substantial portion of the gasoline is produced in the first stage where the conditions are such that olefin saturation and recracking are avoided. While the *total* amount of aromatics in the various gasolines does not vary widely, the *concentration* of aromatics in two-stage gasoline is much lower due to the increased amount of olefins produced.

The somewhat higher sulfur content of two-stage gasoline is also attributed to avoidance of recracking. This

TABLE 4—Comparison of Single-Stage and Two-Stage Cracking of Various Feed Stocks

Crude Source	West Texas			Redwater		Los Angeles Basin	
Feed Properties:							
API gravity	29.1			23.0		25.2	
Sulfur, percent by weight	0.57			0.70		1.25	
Ramsbottom carbon residue, percent by weight	0.15			1.0		0.3	
Precision distillation, percent by volume:							
IBP to 450 F	3			1		1	
450 F to 615 F	35			9		27	
615 F+	62			90		72	
	Single-Stage						
	Single Pass	Total Gas Oil Recycle*	Two-Stage	Single-Stage	Two-Stage	Single-Stage	Two-Stage
Cracking temperatures, degrees fahrenheit	900	900	1,000 to 900	900	1,000 to 900	1,000	1,000 to 950
Catalytic Cracking Yields, percent by Volume:							
Ethane and lighter (std cu ft per bbl)	(190)	(190)	(300)	(195)	(230)	(415)	(290)
Propylene	7.6	7.1	9.5	4.9	7.5	6.4	7.8
Propane	4.2	3.8	3.8	3.2	2.9	3.9	3.7
Butylenes	8.2	8.8	10.9	7.0	8.8	8.1	9.0
Isobutane	9.4	8.3	4.5	5.8	3.9	3.8	4.6
nButane	1.8	1.5	1.5	1.1	0.8	1.1	0.9
Amylenes	4.8	5.5	6.6	4.9	7.6	5.2	6.4
Isopentane	6.5	6.9	3.8	4.5	2.6	2.0	2.5
nPentane	0.3	0.3	0.3	0.4	0.3	0.4	0.1
Depentanized gasoline (113 F to 450 F)	24.2	32.2	37.5	33.5	41.9	28.8	38.6
Light gas oil (450 F to 615 F)	23.5	19.3	16.7	17.9	13.2	22.6	19.4
Heavy gas oil (615 F+)	18.0	14.7	11.2	20.5	12.8	18.9	11.8
Carbon, percent by weight	5.2	5.2	5.2	8.5	8.5	6.5	6.5
Conversion	58.5	66.0	72.1	61.6	74.0	58.5	68.8
Total yield of 10 lb RVP gasoline†	49.9	59.5	67.4	55.5	67.7	50.8	64.8

* Total feed ÷ fresh feed = 1.6.
† Based on polymerization of propylene and butylenes, and blending butane to 10 lb RVP.

increase in sulfur does not present a serious problem with most U.S. crudes; however, special treating techniques will probably be required with some high-sulfur crudes.

Because of the high olefin content and the relatively high diolefin content, extensive stability tests, including an 18-month storage program, were carried out. Since the first-stage gasoline would be expected to be the least stable portion of the total gasoline, it was used in these tests rather than the combined two-stage gasoline. The results of the storage program indicated that the first-stage gasoline, when properly inhibited initially, is as stable as conventional catalytically cracked gasoline.

Engine cleanliness tests were also carried out on the first-stage gasoline. The results of these tests showed that this gasoline is comparable with a typical commercial premium gasoline. The stability of first-stage (and therefore two-stage) gasoline, despite the rather high diolefin content, is attributed primarily to the boiling range of the diolefins. Analysis of several fractions of the gasoline showed that the diolefins are concentrated in the lower boiling portion, which do not contribute markedly to gum formation.

Flexibility is one of the most important considerations in the development of a process. In the Shell two-stage cracking process, considerable flexibility is available for changing the yield structure from any given feed stock. For example, gasoline yield can be increased further by incorporating recycle into one of the cracking stages. On the other hand, in periods of high demand for intermediates, the yield of light gas oil can be increased substantially by charging only heavy gas oil to the second stage.

A comparison of two types of two-stage operation, namely, with total first-stage gas oil and with heavy first-stage gas oil only going to the second stage, is shown in Table 6. These data are on the same basis (5.2-percent-by-weight carbon) as, and therefore comparable with, the West Texas data given in Table 3. The 9-percent increase in light gas-oil yield is realized partly at the expense of heavy gas oil and partly because of the lower total conversion. However, despite the increased light gas-oil yield and the 5 percent lower conversion, the gasoline yield is decreased only 4 percent. Furthermore, the light gas oil produced in this way is of high quality. Of course, gains in yield and quality could be achieved in conventional recycle operation by recycling only heavy gas oil, but the difference between comparable two-stage cracking and recycle cracking operations would be essentially the same as that shown in Table 4. It is significant, however, that the two-stage process operated for maximum intermediates rather than maximum gasoline, i.e., cracking of only *heavy* gas oil in the second stage, produces 3 percent more gasoline than conventional recycle cracking of total gas oil at roughly the same total conversion.

The first commercial unit employing these new techniques was built at Shell's refinery at Anacortes, Wash. A schematic flow diagram of this unit is given in Figure 3. Fresh feed is contacted in a riser reactor with regenerated catalyst. The product vapors and partially spent catalyst are separated, the former going to a fractionator

Meet the Author

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TABLE 5
Properties of Products from Two-Stage and Conventional Catalytic Cracking

	SINGLE-STAGE		
	Single Pass	Recycle	Two-Stage
Carbon yield, percent by weight	5.2	5.2	5.2
Conversion, percent by volume	59	66	72
Product Properties:			
Depentanized Gasoline:			
API gravity	45.5	46.3	46.0
Sulfur, percent by weight	0.08	0.08	0.14
Maleic anhydride value	8	7	18
Hydrocarbon type analysis, percent by weight:			
Olefins	16	26	43
Aromatics	50	44	37
Saturates	34	30	20
Octane ratings (neat):			
Research method +3 cc TEL	98	98	98.5
Light Gas Oil:			
API gravity	28.0	27.3	26
Aniline point, degrees fahrenheit	123	116	113
Kinematic viscosity at 100 F, cs	3.2	3.1	3.0
CFR calculated cetane number[23]	37	35	32
Heavy Gas Oil:			
API gravity	23.5	22	20
Ramsbottom carbon residue, percent by weight	0.8	0.3	0.7
Kinematic viscosity at 100 F, cs	14	13	13

TABLE 6
Two-Stage Yields from Cracking Total First-Stage Gas Oil vs. Heavy First-Stage Gas Oil in the Second Stage

	Second-Stage Feed	
	Total Gas Oil*	Heavy Gas Oil†
Total conversion, percent by volume	72	67
Yields, percent by Volume:		
Debutanized gasoline (IBP to 450 F)	48.2	43.8
Light gas oil (450 F to 615 F)	16.7	25.8
Heavy gas oil (615 F +)	11.2	7.6
Carbon, percent by weight	5.2	5.2
Total 10 lb RVP gasoline, percent by volume‡	67.4	62.7

* Total feed to both stages ÷ fresh feed = 1.6.
† Total feed to both stages ÷ fresh feed = 1.2.
‡ Based on polymerization of propylene and butylenes, and blending butane to 10 lb RVP.

API Process Session

and the latter routed to the second-stage reactor to which gas oil from the first-stage fractionator is fed. Spent catalyst is stripped, regenerated, and returned to the riser reactor.

The unit has operated on a mixture of Alberta feeds since its start-up this January. Typical feed-stock properties are shown in Table 6. Plant yields with this feed mixture are given in Table 7.

The plant exceeded design expectations and has demonstrated ability to operate smoothly without mechanical problems of any consequence.

The principles are not limited to the design of the Anacortes unit. For example, single-stage riser reactor units have been designed to take advantage of the increased selectivity where high conversion is not required, as is the case in some refining situations. Existing fluid units can, in some instances, be modified to take advantage of the short-contact-time and two-stage principles by addition of a riser reactor and other facilities.

Original presentation was before the API Division of Refining Meeting, Montreal, May 15, 1956.

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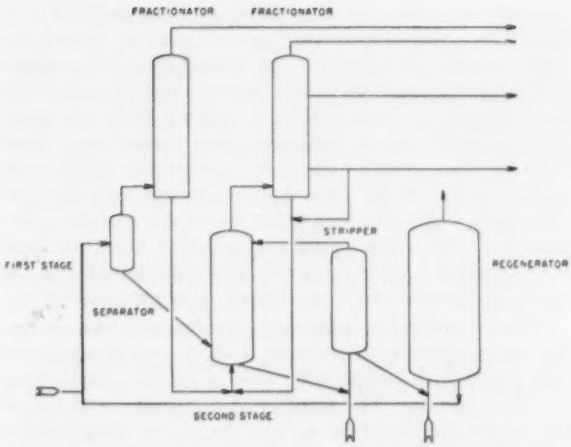

FIGURE 3—Shell's refinery at Anacortes, Washington, employs this new two-stage technique for catalytic cracking.

TABLE 7
Alberta Feed-Stock Properties

API gravity	23.7
ASTM Distillation, Degrees Fahrenheit:	
IBP	508
10 percent by volume	620
Pour point, degrees fahrenheit	+85
Ramsbottom carbon residue, percent by weight	0.83
Sulfur, percent by weight	1.26
Viscosity at 210 F, SSU	51

TABLE 8
Catalytic Cracking of Mixed Alberta Feed Stock at Anacortes

	Yields (Percent by Volume)
Ethane and lighter (std cu ft per bbl)	(340)
Propylene	8.0
Propane	4.5
Butylenes	12.7
Butanes	5.1
Debutanized gasoline	53.3
Light gas oil	12.2
Heavy gas oil	12.4
Coke, percent by weight	6.5
Conversion	75.4

What Do We Know About Cracking?

COMMERCIAL FLUID CATALYTIC cracking is now 14 years old. In that time there have been a number of engineering improvements over the early process. More accurate design data, resulting from studies of fluidization[6, 11, 13, 14] and catalyst transfer,[4, 9, 22] have permitted the height of units to be decreased, thereby reducing construction costs. Improvements in stripping of spent catalyst[10, 16, 18] and in regeneration[11, 19, 20, 21] have provided means of increasing the capacity of existing units or of reducing the costs of new units.

Techniques for improving yields and selectivity in commercial fluid catalytic cracking have heretofore been limited to three types, all of which were recognized in the early conceptions of the process. Recycle of gas oil has been an important tool for improving selectivity.[1, 2, 18] High-temperature cracking[1] reduces coke yield but also reduces gasoline and increases gas make and has therefore been useful only in a few special cases, usually where large quantities of olefins are desired from a relatively high coke-making feed. Lastly, segregation of feed stocks[17] permits cracking each one under conditions more closely approaching optimum than would be possible if the stocks were admixed. This advantage arises from the marked variations in refractoriness found for hydrocarbons of differing molecular weight and molecular type.[7, 8]

Even with feed stock segregation, the boiling range and molecular type spread of a typical catalytic cracking feed stock are so wide that the operating severity required to achieve a given over-all conversion inevitably results in some destruction of the gasoline initially produced from the least refractory components. This shortcoming is intensified by the wide distribution of vapor residence times which is found in the fluid beds of conventional catalytic cracking units,[3, 5, 6, 14] and which would lead to overcracking/undercracking losses even with a feed of uniform composition and narrow boiling range.

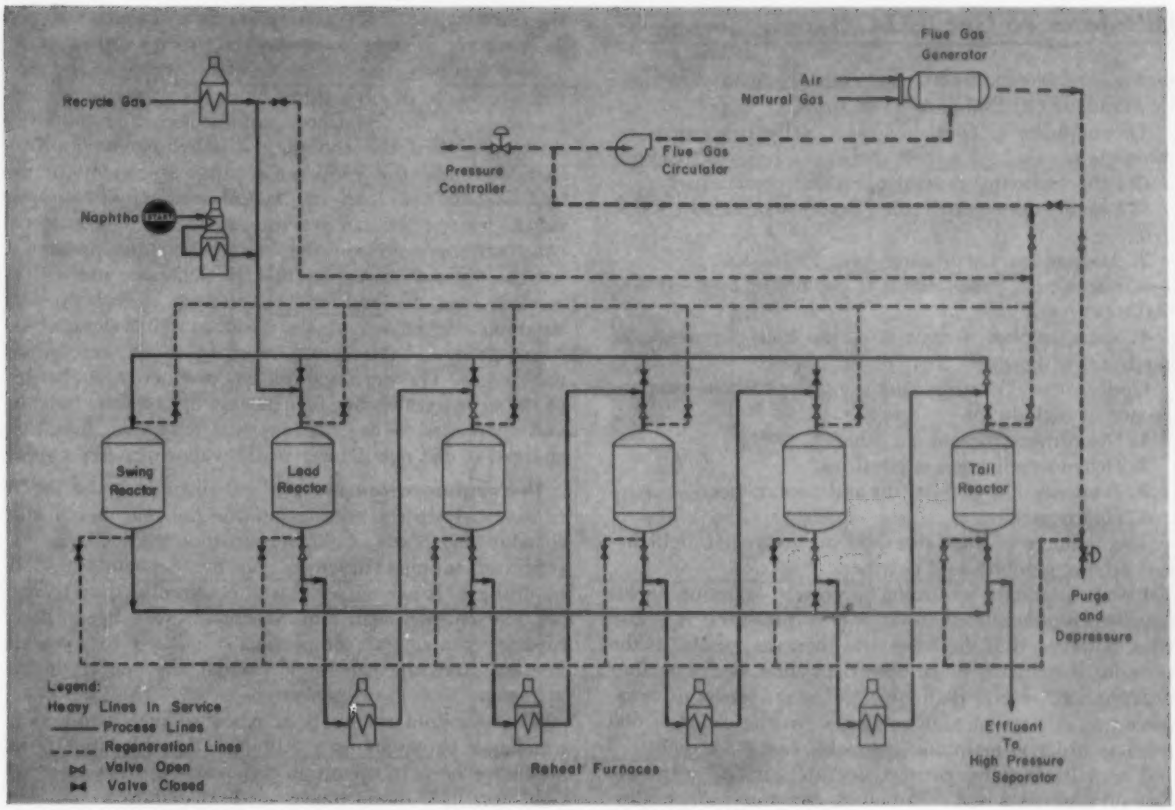

FIGURE 1—Reforming is not interrupted during regeneration since any one of the reactors may be replaced by the swing reactor.

Process Session

Ultraform to Get 100 Octane, Clear

This regenerative platinum reforming process consistently produces a gasoline with 100 research octane.

Philip C. White, W. F. Johnston and W. J. Montgomery
American Oil Company, Texas City, Texas

THE ULTRAFORMER at American Oil Company's Texas City refinery has been in operation for over a year and has successfully produced gasoline of 100 Research octane number, clear, through sustained operation. This unit was designed for 21,200 barrels per stream day, and was brought onstream on February 26, 1955.

The ultraforming process has been described in general by earlier papers;[1,2] however, a brief summary is presented here.

This process is a fixed-bed, multireactor catalytic-reforming process in which low-octane-number naphtha is upgraded to produce high-octane gasoline with maximum gasoline recovery. A superior yield-octane relationship is obtained by operating at low pressures and by using a

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highly selective platinum-on-alumina catalyst, developed by Standard Oil Company (Indiana).

The naphtha is contacted with a hydrogen-rich, recycle-gas stream and passed through a series of reactors, under the following general operating conditions:

1. Reactor-inlet temperature, degrees fahrenheit, 900 to 970.

2. Average reactor pressure, psig, 250 to 350.

3. Recycle-gas ratio, std cu ft per bbl of feed, 3000 to 6000.

4. Space velocity, weight of oil per hour per weight of catalyst, 1 to 4.

Under these operating conditions, the specific reactions occurring include:

1. Dehydrogenation of naphthenes.

2. Dehydrocyclization of paraffins.

3. Isomerization of paraffins and naphthenes.

4. Hydrocracking.

The poducts of these reactions are hydrogen, light hydrocarbons, gasoline, and polymer.

In all platinum-reforming processes, gasoline yields increase considerably at lower reactor pressures. It is also true, however, that the coke yield increases rapidly as the pressure is reduced. Since coke deposition causes catalyst deactivation, early platinum-reforming processes were forced to operate at high pressures (in the order of 600 psig) in order to maintain reasonable catalyst activity.

The Ultraforming process operates at the relatively low pressure of about 300 pounds per square inch gage and is thus able to achieve much higher gasoline yields. Catalyst activity is maintained through the cyclic regeneration of the reactors. As each reactor becomes deactivated, it is replaced by a swing reactor and regenerated while the other reactors remain in process service. The regeneration process goes beyond the mere removal of coke from the catalyst. A special regeneration technique maintains the catalyst at a high-activity level, even after many regeneration cycles.

In addition to the obvious advantages of higher yields and octanes, and longer catalyst life resulting from long-term activity maintenance, the Ultraforming process has several other advantages: a wide range of operating conditions applicable to a variety of feed stocks, quick recovery of activity lost due to operating upsets, and startup operation without hydrogen for pressuring.

The reactor system at the Texas City unit essentially consists of six reactors, recycle-gas and naphtha-preheat furnaces, and four reheat furnaces. Only five of the reactors are on process at one time. The sixth, called the swing reactor, is used as a substitute for any of the other five during their regeneration. The physical arrangement of the reactors is unique. Instead of lining up the six vessels in a row, five of them are arranged in the form of a pentagon with the swing reactor in the center of the pentagon. This arrangement represents substantial savings in manifold piping.

The reactor and regeneration systems are diagrammed in Figure 1. The naphtha charge is vaporized in the preheat furnace, combined with hot recycle gas, and charged to the lead reactor at a combined transfer-line temperature of 920 F to 960 F. Since the primary reforming reactions are endothermic, temperature drops occur across the reactors, and it is necessary to reheat the effluent from each reactor in order to return the process vapors to the desired reaction temperature before charging to the next reactor. As the process vapors move progressively through the reactors, the reformed naphtha becomes more refractory toward the endothermic-dehydrogenation reaction, and thus the temperature drop is greatest in the lead reactor and least in the tail reactor. The process vapors leaving the tail reactor are cooled in a series of heat exchangers, comprising the reboilers and preheaters for the various towers in the fractionation and vapor-recovery sections and are charged to a high-pressure separator. A portion of the hydogen-rich separator gas is compressed, heated, and returned to the reactors as recycle gas. The net separator-gas production is charged to the primary absorber for recovery of propane, butanes, and pentanes. The high-pressure-separator liquid is charged to the debutanizer in the vapor-recovery system.

The regeneration-system flow diagram is also shown in Figure 1. In this illustration, the tail reactor is in the coke-burning phase of the regeneration cycle. A flue-gas generator supplies the inert gas by the combustion of natural gas. It also serves as a direct-fired furnace to supply regeneration-heat requirements. A low-head, high-capacity centrifugal compressor is utilized to circulate flue gas from the generator through any one of the reactors and back to the generator.

The manifold system is designed so that a minimum number of valves are used. Although they are large in size and have been in operation frequently during regeneration, very little maintenance has been required.

The complete regeneration cycle consists of a number of sequential operations requiring about 20 hours for completion. These operations are performed automatically through the operation of double-disc motor-operated valves, the movements of which are controlled by a master cycle timer. If desired, the valves may be operated manually or by push button from the control room. Electrical interlocks are provided to eliminate the possibility of operating the wrong valve. Operating labor for regeneration is nominal, requiring only part of the time of two men.

In order to ensure against contact of process vapors and oxygen-containing regeneration gas, inert seal gas is introduced between the valve discs. The seal gas is automatically introduced when a valve is in the closed position, and differential-pressure controllers are provided to maintain the seal-gas pressure on the valve bonnets, 10 psig higher than the pressure on the process side of the valves. Flow indicators are also provided on the sealing-gas lines to determine when seal-gas leakage is excessive. In the event of an equipment failure in the seal-gas-generation system, 415-pound steam may be used as a sealing medium.

The feed is desulfurized before charging to the Ultraforming process. The hydrodesulfurization facilities were not included in the original design of the unit since Ultraforming catalyst performs satisfactorily with feed stocks containing up to 300 ppm or more of sulfur. Sulfur levels, of the order of magnitude existent in our feed, however, did cause equipment corrosion. After a few months of operation, the need for desulfurization in order to prevent the formation of scale became evident. For this reason, an old fixed-bed hydroforming unit was converted

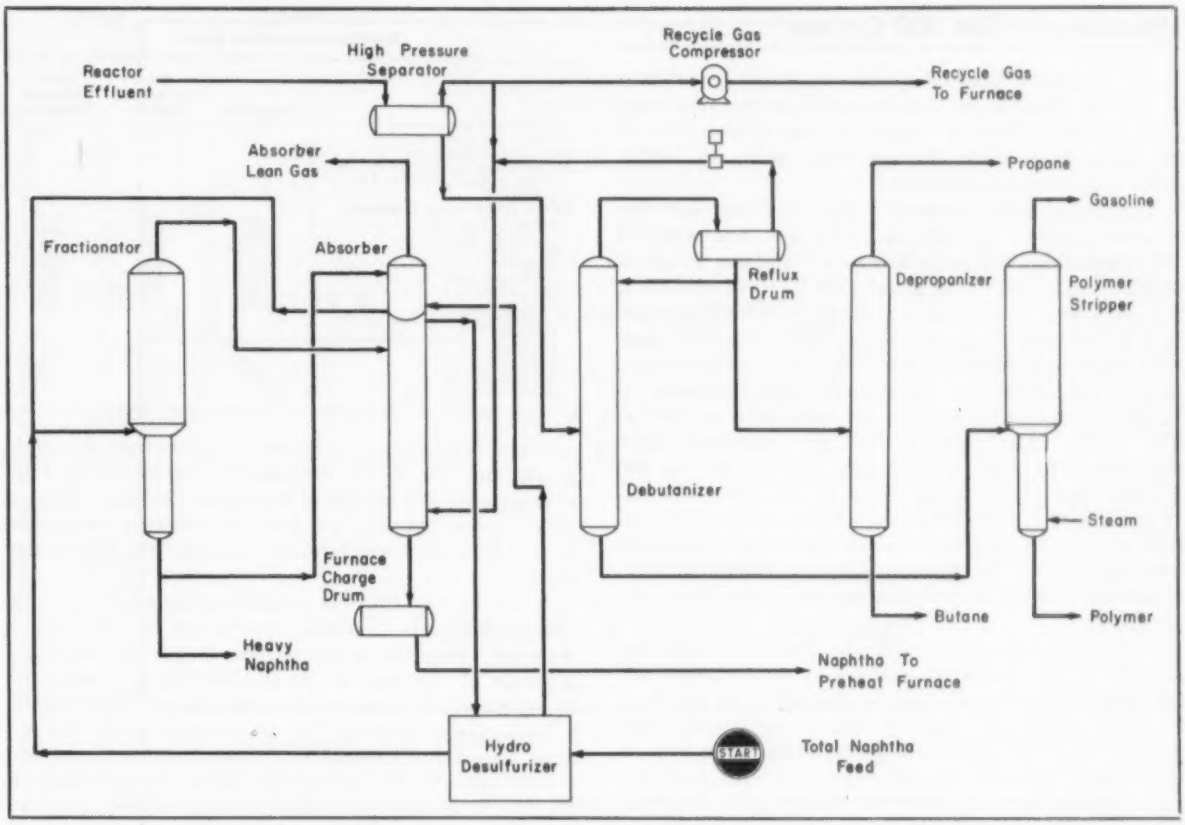

FIGURE 2—The feed is hydrodesulfurized by using the make gas from the ultraformer as a hydrogen source.

to a hydrodesulfurizer, using make gas from the Ultraformer as a hydrogen source. This unit gives very effective desulfurization.

A schematic flow diagram for the feed preparation and vapor-recovery system is shown in Figure 2.

The desulfurized naphtha is charged to the prefractionator tower at the Ultraforming unit. In this tower, the charge is fractionated to a final boiling point (ASTM FBP) of 400 F. The naphtha overhead is charged as lean oil to the absorber tower, and the rich oil from the bottom of the absorber is charged to the naphtha-preheat furnace. A slip stream of prefractionator bottoms is used as lean oil in the sponge section of the absorber; the rich sponge oil is returned to the prefractionator.

The lean primary-absorber gas, rich in hydrogen, is charged to the hydrodesulfurization unit. The effluent gas from the desulfurizer is returned to the Ultraformer sponge absorber, and the lean gas from this section is used as fuel in the unit furnaces.

The high-pressure-separator liquid is charged to a debutanizer tower where a C_3 to C_4 cut is taken overhead. Since the charge to this tower contains small quantities of extremely light materials (ethane, methane, and hydrogen), total condensation of the debutanizer overhead stream at a reasonable pressure is not possible. This stream is partially condensed and the vapor from the reflux drum is compressed and returned to the absorber. Debutanizer-reflux-drum liquid is charged to a C_3 to C_4 splitter.

The bottoms from the debutanizer are charged to a polymer stripper tower where the total C_5+ reformate is fractionated to 400-F ASTM FBP.

The materials of construction for the reactor shells are A-204 grade B FBQ carbon steel (0.5 percent molybdenum). An internal liner is provided consisting of 4 inches of insulating cement secured to the vessel walls on stainless-steel Nelson studs. A cylindrical shroud is also provided. It is welded to the top of the shell and is free at the bottom. Furnace tubes and transfer lines are low chrome-moly steel.

Two major difficulties were encountered during the early operation of the unit. The first of these was high-reactor-pressure drop. Design-pressure drops were less than 15 psi. At the beginning of Run No. 1, excessive pressure drops were being experienced in all reactors. The pressure drop in the tail reactor began to increase while on gas circulation prior to charging naphtha, and finally reached a high of 122 psi after 56 hours onstream. When the unit was shut down, it was discovered that extensive catalyst attrition had occurred as a result of the impingement of high-velocity process vapors (150 to 250 feet per second) entering the top of the reactor. The catalyst dust resulting from the attrition had plugged the beds. In order to prevent further catalyst attrition, three steps were taken. First, a modified inlet-nozzle distributor was pro-

vided. Second, a layer of alumina balls was provided as a cover for the catalyst. Third, a series of revetment rings was installed in the ball layer to prevent displacement of the balls. Since these changes were made, no further catalyst attrition has occurred.

The second major problem in the early unit operation was the problem of corrosion. The unit was operated initially with an undesulfurized feed containing 250 ppm to 300 ppm sulfur. After about 1500 hours of operation, hot tubes were observed in several of the reheat furnaces, and, in addition, it appeared that reactor pressure drops were increasing. When the unit was shut down for inspection, it was found that the furnace tubes contained up to one-eighth inch of a hard scale which was analyzed as iron sulfide. The transfer lines also contained large amounts of this scale, and the scale had carried into the reactors where it had plugged the catalyst beds. The top 10 percent of the catalyst in each bed was found to contain about 20 percent corrosion products. Metal-loss measurements in the furnace tubes indicated that corrosion rates of 50 to 150 mils per year were being experienced.

The corrosion experienced at the Texas City unit was a result of high-temperature attack by the hydrogen sulfide formed by the reduction of the sulfur in the feed. This type of corrosion is not peculiar to the Ultraforming process. Since this initial difficulty, it has been learned that many types of catalytic-reforming units have experienced similar difficulties. From laboratory investigations and from actual plant experience, the following conclusions may be drawn:

1. Hydrogen sulfide in a hydrogen atmosphere will readily attack most steels at temperatures above 400 F.

2. Sulfur concentrations in the feed, even as low as 100 ppm, may result in hydrogen-sulfide concentrations in the total process vapors sufficient to result in moderate to severe corrosion rates at the temperature at which most reforming processes are operated.

3. Even moderate corrosion rates will cause scale in sufficient quantities to plug catalyst beds.

4. Low-chrome alloy steels offer little more corrosion protection than carbon steel. In some cases, low alloy steels are not as resistant to attack as carbon steel. It is usually necessary to go to 18-8 stainless steel to obtain good protection.

5. Aluminum-coated steels offer good protection against attack.

In order to eliminate further sulfide attack in the Texas City Ultraformer, it was decided to desulfurize the feed to well below 100 ppm. After 2,300 hours' operation on desulfurized feed, the unit was inspected and corrosion was negligible.

The present charge to the commercial unit is a mixture of virgin naphtha derived from Gulf Coast, East Texas, and West Texas sweet crude oils. It is an excellent reforming charge stock because it has a high naphthene content. Table 1 gives inspection data for the raw charge to the desulfurizer, the desulfurized naphtha charge to the prefractionator, and the fractionator overhead stream.

It is necessary to operate the Amoco Ultraformer at very high severity because of the demand for high-octane-

TABLE 1
Naphtha-Inspection Data

	Naphtha	Desulfurized Naphtha	Fractionator Overhead
Gravity, deg. API	50.0	50.7	50.8
Reid vapor pressure, psi	....	....	1.2
ASTM octane number (D 908, research method), without TEL addition	....	....	51
ASTM Distillation, Degrees F.			
Initial boiling point	205	206	200
10 percent point	254	252	254
30 percent point	280	280	278
50 percent point	304	305	303
70 percent point	328	326	324
90 percent point	367	370	354
Final boiling point	420	422	400
Hydrocarbon Type, Percent by Volume:			
Paraffins	....	....	33
Olefins	....	....	0
Naphthenes	....	....	53
Aromatics	....	....	14

blending components. In Figure 3, a plot of the Research octane number of the debutanized 400-F ASTM FBP reformate for the months of December 1955 and January 1956 is presented. Reforming severity changes were made in mid-December and January to bracket the 100 octane level.

It can be seen that the octane number seems to cycle. The higher coke laydown experienced at the higher severities causes the octane number to fluctuate with the sequence of regeneration. At this severity, it is necessary to regenerate the reactors frequently in order to maintain a high catalyst activity. On the average, about one reactor per day is regenerated. Coke laydown is considerably higher in the last reactors in the series because of the lower pressures and higher average reactor temperatures. Frequency of regeneration for a particular reactor thus depends on its location in the series. The last three reactors and the swing reactor are regenerated on oil every 70 hours. The lead reactor is regenerated after 300 hours, and the second reactor is regenerated after 150 hours.

At the present high-severity operation, a catalyst life of at least 60 barrels of charge per pound of catalyst is expected. The present charge of catalyst has undergone an average of 65 regenerations per reactor and has achieved a life of 22 barrels of charge per pound of catalyst.

TABLE 2
Product Yields

	PRODUCT OCTANE NUMBER			
	97		100	
	Percent by Volume	Percent by Weight	Percent by Volume	Percent by Weight
H_2	....	1.9	....	2.1
C_1	....	1.0	....	1.5
C_2	....	2.4	....	3.5
C_3	....	4.4	....	5.3
C_4	6.6	4.9	7.5	5.4
C_5	6.5	5.3	7.5	6.1
C_6 to 400 F.	72.2	76.9	67.6	72.9
Polymer	2.6	3.2	2.6	3.2
	....	100.0	....	100.0

Average yield data are shown in Table 2 for the commercial unit at two reformate octane numbers. The charge stock for this operation was the same as the one presented in Table 1. These data agree very well with pilot-plant-yield data, which are discussed in the next section.

Inspection data for the gasoline and polymer produced

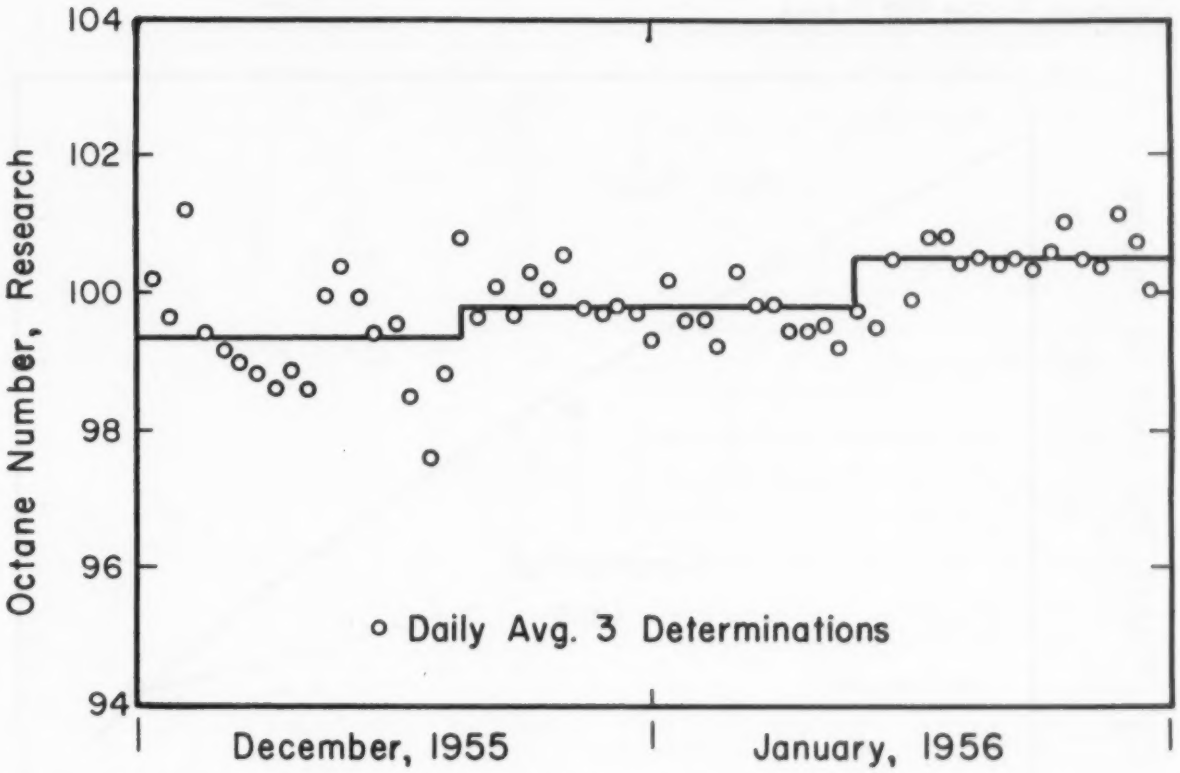

FIGURE 3—The ultraformer is operated at very high severity to satisfy the demand for high-octane blending components.

in these operations are shown in Table 3. This gasoline is the debutanized 400-F ASTM FBP rundown product as it comes off the unit. The ASTM FPB for the total C_5+ reformate before rerunning would be about 490 F. The Research octane number of this material would be 0.1 to 0.3 units higher than for the 400-F ASTM FPB material at the 95 to 100 octane level.

Pilot-plant studies are made to help in the operation of Amoco's commercial Ultraforming unit. A 1-barrel-per-day Ultraforming pilot plant was designed to duplicate the commercial operation. This pilot unit was constructed with six reactors including a swing reactor, and manifold piping to allow the swing reactor to replace any of the others for regeneration, just as in the commercial unit.

This switching of reactors takes place every day during operation of the pilot plant. By operating in this manner the catalyst activity can be maintained, so that smooth, continuous operation at high-octane-number results. It is advantageous to operate a pilot plant in this manner to obtain the best information concerning commercial-unit performance. Studies on this pilot plant have shown that coke yields duplicate those of the commercial unit; catalyst activity can be predicted accurately; and gasoline yields can be obtained which can be reproduced in commercial operation. Figure 4 is an illustration of the good comparison between pilot-plant and commercial-unit yields. Both pilot-plant and commercial-unit data were obtained with the charge stock shown in Table 1.

The conditions employed in the pilot plant were those obtainable in the commercial unit as originally designed. Recent developments have shown that operation under somewhat modified conditions will result in a yield increase of 3 percent to 3.5 percent. Modification of the commercial unit to realize this further yield advantage is planned.

The pilot plant has been used to determine the effect of feed stock on Ultraforming yields. In Table 4, the hydrogen, dry gas, butanes, and C_5+ yields are shown for a variety of naphthas. Also included are thermal gasolines and visbreaker gasolines which have been hydro-

TABLE 3

Inspection Data for Debutanized Gasoline and Polymer

	97 Octane		100 Octane	
	Gasoline	Polymer	Gasoline	Polymer
ASTM OCTANE NUMBER				
D 908, research method, without TEL addition	97.0	....	100.1	....
D 357, motor method, without TEL addition	86.0	....	87.9	....
Gravity, deg. API	44.3	11.3	43.5	9.5
Reid vapor pressure, psi	5.1	....	7.0	....
ASTM Distillation, Deg. F.:				
Initial boiling point	115	450	106	460
10 percent point	183	464	180	480
30 percent point	249	468	248	500
50 percent point	285	480	284	508
70 percent point	314	494	314	523
90 percent point	350	530	346	588
Final boiling point	396	680	408	700+
Hydrocarbon Type, Percent by Volume:				
Paraffins	32	....	22	....
Olefins	1	....	....	....
Naphthenes	1	....	3	....
Aromatics	66	99	75	99

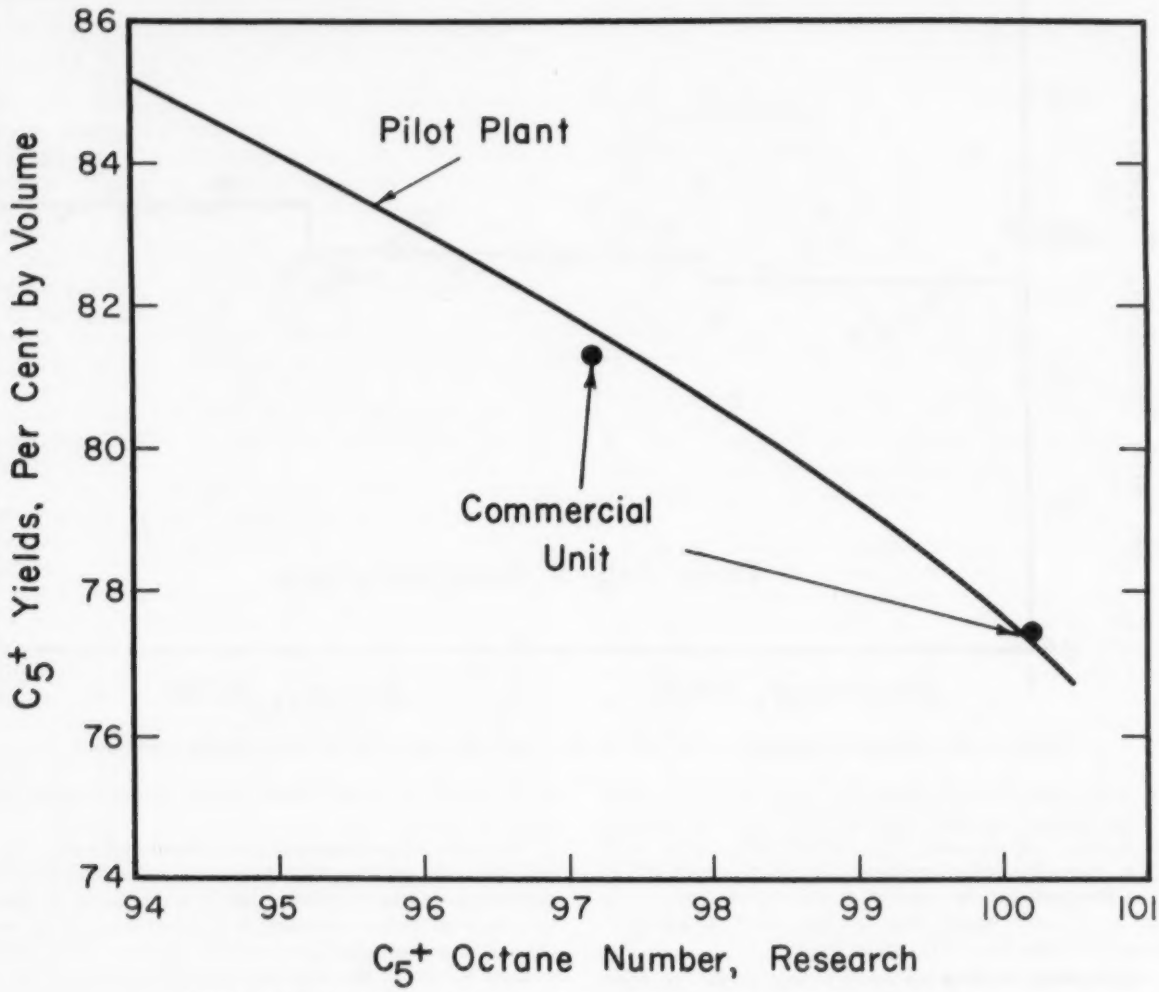

FIGURE 4—A pilot plant is used to determine the best operating conditions for the commercial unit.

fined prior to reforming. The yields are shown at the 95 and at the 100 octane levels. Inspection data for the various feeds are shown in Table 5. These pilot-plant data further illustrate the high yields that can be obtained by Ultraforming.

Other pilot-plant studies are continuing on the operating conditions, regeneration, the effect of feed stocks, etc. These studies, both at American Oil Company and in the laboratories of Standard Oil Company (Indiana), are being made in order to define the best processing

TABLE 4
Ultraforming Yields

	Coastal Heavy Naphtha A		Coastal Light Naphtha		Coastal Heavy Naphtha B		Mid-Continent Naphtha	
ASTM octane level (D 908, research method), without TEL addition	95	100	95	100	95	100	95	100
Hydrogen, percent by weight	1.9	2.1	2.3	2.4	2.1	2.3	2.0	2.1
Dry gas, percent by weight	8.6	10.6	7.0	10.6	5.0	9.0	8.5	11.6
Butanes, percent by weight	6.0	7.7	5.3	7.5	2.0	6.6	6.2	8.5
C_5+, percent by volume	83.0	79.1	84.0	77.0	89.0	81.9	81.9	76.6

	Mixed Coastal Naphthas		Tia Juana Heavy Naphtha		Hydrofined Thermally-Cracked Naphtha		Hydrofined Visbreaker Naphtha	
ASTM octane level (D 908, research method), without TEL addition	95	100	95	100	95	100	95	100
Hydrogen, percent by weight	2.0	2.1	1.5	1.6	1.4	1.6	1.8	2.0
Dry gas, percent by weight	7.8	11.4	9.3	12.8	7.4	10.7	8.6	10.8
Butanes, percent by weight	4.0	8.3	6.0	10.6	5.5	8.4	5.0	7.3
C_5+, percent by volume	84.2	77.8	83.5	75.0	84.9	78.1	84.0	77.7

TABLE 5

Charge-Stock Inspections

	Coastal Heavy Naphtha A	Coastal Light Naphtha	Coastal Heavy Naphtha B	Mid-Continent Naphtha
Gravity, deg. API	51.1	57.4	46.9	55.6
ASTM Distillation, Degrees Fahrenheit:				
Initial boiling point	226	208	231	206
10 percent point	256	215	261	226
30 percent point	282	220	248	256
50 percent point	304	226	308	276
70 percent point	326	235	334	300
90 percent point	358	256	367	334
Final boiling point	408	316	412	376
ASTM octane number (D 908, research method), without TEL addition	45.2	60.0	61.0	44.0
ASTM octane number (D 357, motor method), without TEL addition	45.1	58.0	60.0	45.6
Sulfur, percent by weight	0.030	0.008	0.011	0.027

	Mixed Coastal Naphthas	Tia Juana Heavy Naphtha	Hydro-fined Ther-mally-Cracked Naphtha	Hydro-fined Vis-breaker Naphtha
Gravity, deg API	50.0	52.4	50.7	49.3
ASTM Distillation, Degrees Fahrenheit:				
Initial boiling point	227	238	240	264
10 percent point	257	254	252	276
30 percent point	282	270	272	295
50 percent point	305	290	296	319
70 percent point	328	314	324	346
90 percent point	360	356	354	381
Final boiling point	409	402	416	424
ASTM octane number (D 908, research method), without TEL addition	48.5	47.7	50.4	39.6
ASTM octane number (D 357, motor method), without TEL addition	48.1	48.0	52.8	40.0
Sulfur, percent by weight	0.026	0.019	0.0002	0.0003

TABLE 6

Operating Costs for 21,200-Bbl-Per-Stream-Day Ultraformer to Produce 100 Research Octane Number Gasoline, Clear

	Ultraforming
Operating Costs, Cents per Barrel on Charge:	
Operating labor at $2.75 per hour	2.8
Laboratory	1.8
Utilities:	
Fuel at 15 cents per million Btu	4.7
Power at 0.8 cents per kwh	2.7
Steam at 30 cents per 1,000 lb	1.9
Water at 1 cent per, 1,000 gallons	
Catalyst	7.1
Maintenance at 3 percent of investment per year	2.8
Taxes and insurance at 2 percent of investment per year	1.8
Total operating costs, excluding royalty, depreciation, administration, and overhead	25.6

conditions for new feed stocks and to to evaluate additional catalyst developments.

Commercial-unit operating costs—Operating costs for the Amoco Ultraformer are shown in Table 6. Labor- and utility-cost figures are representative values for an average refinery. The data show that Ultraforming is an economical route to 100 octane gasoline, since the total direct operating cost is only about 25 cents per barrel.

Original presentation was before the API Division of Refining Meeting, Montreal, May 15, 1956.

LITERATURE CITED

[1] Standard Oil Company (Indiana), "Ultraforming," *Petroleum Refiner*, 33 [9], 162-63 (1954).

[2] J. H. Forrester, A. L. Conn and J. B. Malloy, "Ultraforming—New Reforming Process," *Petroleum Refiner*, 33 [4], 153-56 (1954).

Catforming in Canada . . . and a report on platforming . . .

Canadian refiners are keeping abreast: Industry trends and automotive gasoline quality requirements are being met by Canadian refineries by adding octane quality improving processes to their rapidly expanding plant facilities. Of the several available platinum catalyst reforming processes used to convert low octane naphthas to premium quality gasolines, the Catforming process has been selected for use in several Canadian refineries. This process utilizes a unique and distinctive type of platinum catalyst. It is a development of and is licensed by The Atlantic Refining Company, Philadelphia.

The first Canadian Catformer has demonstrated a wide flexibility in converting a straight run naphtha to quality fuels of 91 to 98 octane. These results have been obtained in constant yield over an extended period of catalyst life, starting in February 1955 and still continuing.

The utilitization of a high cost noble metal in catalyst used in large volume refinery processes has weathered the "anxiety stage." Extended commercial experience with Catforming has demonstrated excellent process economy resulting from high yields and long catalyst life.

("Catforming for High Octanes in Canada," H. R. Crane and J. A. Nevison, The Atlantic Refining Company, Philadelphia.)

Octanes Still Going Up: The consistently upward trend in octane number requirements for automotive fuels has thrown an additional burden on refiners to process crude oil in such a manner as to satisfy the needs of present-day automobiles as well as future models.

For the last seven years more and more reliance has been placed upon a new refining process to supply these ever-increasing needs. This process, developed by Universal Oil Products Company, is called Platforming and utilizes a platinum-containing catalyst for the conversion of the low octane components of crude oil into high octane fuels. Intensive studies concurrent with the ever-increasing commercial application of the Platforming process have made it possible to improve the catalytic material so that the gasoline consumer of the future need not face an octane number ceiling. The improvement in the catalyst has a twofold effect. Not only does it provide for the production of higher octane fuels, but it also does so with higher yields than heretofore possible, thereby conserving crude oil as a source of energy. As an example of the improved fuels it can be said that, whereas six years ago the average premium gasoline had an octane number of 90.5, and today it is in excess of 96, the Platforming process utilizing the new catalyst makes it possible to produce fuels having octane numbers of 100 and higher.

("Platforming—A Progress Report," Vladimir Haensel and D. H. Belden, Universal Oil Products Company, Des Plaines, Ill.)

API Process Session

Smoke & Fumes Session

Research Committee Reports

The results of three years' work are reviewed along with plans for the coming year. Nearly $750,000 spent on 10 research projects.

L. C. Kemp, Jr.
The Texas Company
New York City

THE SMOKE AND FUMES COMMITTEE'S program of fundamental research on air pollution, as related to the transportation, refining, and use of petroleum and its products, is nearing the end of its third full year of operation. During this period almost $750,000 has been spent on 10 research projects. The results of this research program is reported here.

Four new projects are being started. Close liaison is maintained with other groups working on the problem, and every effort is made to avoid duplication of the work of others and to obtain useful information from the committee's research projects. The projects already have made substantial contributions through the development of improved analytical devices and methods, through provision of more reliable information on the sources of pollutants, and through the development of new and important information on the reactions of pollutants in the atmosphere. Much valuable information should come from the work to be done in the future.

COMPLETED RESEARCH

Armour Research Foundation, Chicago

Aim—Determination of the amount of hydrocarbons and partially burned hydrocarbons present in the flue gases from domestic and industrial burners using petroleum products.

Findings—In all cases tested less than 100 ppm of hydrocarbon or derivatives in the flue gas. In almost all cases there was less than 50 ppm, and in most cases there was no detectable amount of hydrocarbon.

Conclusions—The contribution of stationary combustion processes using petroleum products to the organic material emitted to the atmosphere is not serious.

University of Cincinnati, Kettering Laboratory

Aim—Survey of the so-called oxidant (expressed as ozone) and oxidant-precursor content in several American cities.

Findings—Oxidant was recorded in four types of cities:

- Heavy automobile traffic and minimum industry, e.g., Washington, D. C.
- Oil refining plus general heavy industry, e.g., Philadelphia, Pa.
- General heavy industry with minimum of oil refining, e.g., Akron, Ohio.
- Heavy concentration of chemical industry, e.g., Charleston, W. Va.

In all the cities surveyed, the oxidant recorded was in the low range typical of Los Angeles under non-smog conditions. Measurements of SO_2 concentration at the same time showed that all of the cities investigated had more sulfur dioxide in their atmosphere than does Los Angeles. It was found that as the sulfur dioxide increased, the oxidant decreased. A more detailed study made under conditions when little sulfur dioxide was found, showed higher oxidant values than when the SO_2 concentration was higher. This relation held for oxidant precursors as well.

Conclusions—That elimination of SO_2 emissions to the air does not result in lower oxidant formation and may actually permit the oxidant concentration to reach higher levels than would be the case if sulfur dioxide were present in larger amounts.

PROJECTS NOW BEING COMPLETED

Stanford Research Institute

Aim—

1. The development of methods for determining the oxidant-forming potential of polluted atmospheres.

2. The mechanism by which ozone and other oxidants are formed in the atmosphere.

Findings—

1. The method of measuring oxidant with potassium-iodide recorders was developed.
2. The method of determining oxidant-precursor values was developed.
3. That materials in the atmosphere which did not possess oxidant properties would form oxidant upon irradiation with natural or artificial light.
4. That nitrogen dioxide in the atmosphere was the key to this photochemical reaction.

Conclusion—The mechanism of the reaction which occurs after the primary photochemical process involving the nitrogen dioxide is very complicated and has not yet been unraveled. Some reaction products have been identified by others and it is believed that the mechanism will soon be clarified.

Industrial Hygiene Foundation of America

Aim—To develop a method for tracing the path of gases after emission from a stack to any point downwind.

Findings—Antimony oxide in a finely divided suspension in the stack gases can be detected and collected downwind by a sampler developed by the Foundation.

Conclusions—This should provide a useful tool for the petroleum industry and others active in air-pollution control.

PROJECTS NOW BEING TERMINATED

Armour Research Foundation

Aim—To develop a quantitative method for analyzing ozone in the atmosphere and a portable instrument to perform the determination.

Findings—A catalytic method was developed based on the measurement of the heat released when ozone is catalytically decomposed to molecular oxygen.

Conclusion—Present laboratory tests indicate complete success with the development. Its adoption hinges upon full scale field tests in the Los Angeles area.

University of Illinois

Aim—To determine the oxidation of sulfur dioxide to sulfur trioxide under conditions which may exist in the atmosphere.

Findings—

1. That the oxidation is very slow.
2. The formation of sulfur trioxide from gaseous sulsur dioxide cannot account for the reduction of visibility observed in atmospheres during a few hours of daylight.
3. It cannot account for the high sulfate content of particulate matter found in some cities.

Conclusions—That the elimination of SO_2 emissions will have little effect in reducing the undesirable results of atmospheric pollution.

PROJECTS BEING CONTINUED

University of Illinois

Aim—To study the rate at which visibility may be reduced or other manifestations of polluted atmospheres may appear as a result of the reaction of hydrocarbon and ozone in the presence or absence of other materials.

Findings—Nothing to report at this time.

The Franklin Institute

Aim—The development of the long-path infrared cell for studying atmospheric reactions.

Findings—The instrument has been developed and has made considerable contributions to the study of atmospheric reactions.

Conclusions—The work will continue with increased emphasis.

NEW RESEARCH PROGRAM

The Franklin Institute

Aim—The construction of another long-path infrared cell for studies of the concentrations of materials in the atmosphere. This new cell will be semi-portable.

Program—The new cell will be first located in Pasadena, Calif., and studies with it integrated with those of the Air Pollution Foundation. The simultaneous determination of materials by this highly sensitive cell will be valuable in determining what is going on in the air. Making the cell portable will allow these measurements to be made at different locations. The method employed gives unequivocal determinations of ozone and some other materials and it is possible that the instrument or some modification of it will be of interest for atmospheric monitoring purposes.

Bureau of Mines, Bartlesville, Okla.

Aim—Survey to determine the amount of organic material, nitrogen dioxide, nitric oxide, and carbon monoxide emitted by automobiles under actual city-driving conditions.

Program—An analytical technique, which employs the principals of gas chromatography is being applied for detailed analyses of exhaust gases. Development of this method of analysis will allow much more detailed studies of exhaust-gas composition than has been possible to date.

NEW RESEARCH PROGRAM

University of California, Riverside, Calif.

Aim—To determine the effect on plants of the newly identified reaction products of atmospheric pollution.

Program—These materials will be tested on actual growing plants by a plant pathologist. The project will be integrated with the one at the University of Illinois and Air Pollution Foundation projects relating to eye irritation. This project should provide valuable information concerning the reaction products which are the real culprits in the atmosphere.

Two Outstanding Men

Aim—To study all possible methods which might be used to isolate and indentify all the constituents present in a polluted atmosphere.

Program—All the possible methods of analyses are under study. These techniques range from gas chromatography to wet-chemical analysis. Work of all the other investigators will be reviewed as part of this study. The availability of complete and reliable methods of analysis of the atmosphere for other than the usual constituents is necessary to determine causes and cures of air pollution.

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The Smoke and Fumes Committee is making every effort to integrate its research program with all the

other work going on in the country. This is no small task. Others active in this program are:

- The Air Pollution Foundation with an annual budget of one-half to one million dollars.
- The U. S. Public Health Service with a budget of up to five million dollars.
- Many states, counties, and cities are carrying out work which totals a large sum.

The petroleum industry is aware of its responsibility as a member of the many communities of this country. The Smoke and Fumes Committee is being supported in its research program at an expense to the industry of about $250,000. It feels strongly the responsibility of seeing that these funds are spent wisely. It is believed that the program to date has produced substantial results. It is to be expected that, with the very fine cooperation and active interest in the projects shown by the project workers and by the many able representatives from industry on the various committees, even greater progress will be noted in the future.

Original presentation was before the API Division of Refining meeting, Montreal, May 16, 1956.

Meet the Author

L. C. KEMP, JR., joined The Texas Company as a research chemical engineer at Port Arthur in 1929, following his graduation from Rice Institute with a degree in chemical engineering. Since then he has been assistant chief chemist in charge of research; assistant superintendent of research at Texaco's Beacon, N. Y., laboratories; director of research and assistant manager of the Technical and Research division in New York; assistant to the vice president of refining, and assistant to the senior vice president. In 1955, when Texaco created its Petrochemical department, Kemp was promoted to general manager.

A report on recent developments . . .

Organic Chemistry of Atmosphere:—A long-path infrared cell, with which it is possible to detect many compounds in air at concentrations in the ppm range is being used at the Franklin Institute Laboratories to study reactions of air pollutants. Field studies of the Los Angeles smog by other investigators have shown that photochemical reactions caused by sunlight play an important role in its development. In the Institute laboratory, it has been demonstrated that ozone is formed when mixtures of nitrogen dioxide with an organic compound in air are irradiated with artificial sunlight. This will account for the abnormal amounts of ozone found in the Los Angeles atmosphere during severe smog attacks. This paper presents the results of further studies on this and other reactions of importance in air pollution chemistry.

Infrared analysis of the products of the photochemical reaction between nitrogen dioxide and an organic compound frequently reveals, in addition to bands of known compounds, several unidentified absorption bands which apparently belong to a single compound produced in significant quantity. Although this compound is unstable, moderately pure samples of it can be condensed if the reaction products are drawn through a cold trap. Physical and chemical properties of this condensate, referred to as compound *X*, are consistent with the belief that it is an acyl nitrogen compound, but its structure is not unequivocally determined. The importance of compound *X* in an explanation of the chemistry of the atmosphere is stressed.

Samples of catalytically cracked and thermally cracked gasoline were photochemically reacted with nitrogen dioxide in oxygen. Ozone was produced at substantially the same rate in both cases. At low concentrations the amount of ozone formed was more than twice the initial amount of nitrogen dioxide. Concentration of reactants and products were observed as a function of time. An explanation of these results is offered.

Ozone is formed when compound *X* is irradiated, with or without added gasoline. Ozone formation is slower with added gasoline, perhaps because the olefins present in the gasoline react with some of the ozone. Ozone is also formed when n-butyl nitrite is photolyzed in oxygen. It is not necessary to have a nitrogen-containing compound present in order to form ozone, for small amounts are formed when diacetyl in oxygen is irradiated with artificial sunlight. This ozone was identified in the presence of interfering methyl alcohol by a subtraction technique.

The rate of formation of ozone was only slightly changed when sulfur dioxide was present in an irradiated mixture of olefin with nitrogen dioxide. Since the sulfur dioxide disappeared very slowly it was concluded that neither the ozone, the free radicals, nor any peroxides that are formed will oxidize sulfur dioxide to sulfur trioxide at a significant rate.

("Recent Developments in the Study of the Organic Chemistry of Atmosphere," E. R. Stephens, P. L. Hanst, R. C. Doerr, and W. E. Scott, The Franklin Institute, Philadelphia.) # #

Waste Disposal Session

How New Is the Waste Disposal Problem?

Here's a quick chronological history of the accomplishments of the Committee on Disposal of Refinery Wastes.

W. B. Hart
Pantech, Inc., Folcroft, Penn.

THE LIGHT ENDS of the Pennsylvania type of crude oil had presented a problem. They were highly flammable, boiled at practically atmospheric temperatures, and had no real use. Consequently, they were deliberately discarded, with no particular concern for any damage they might do or fire hazard they might create. These light ends, or much of what we know as gasoline today, thus became the first pollutant resulting from oil-industry activity.

Just prior to 1900 some people got the idea that somehow these light ends could be used. So work was begun on the development of an engine in which they would be burned as fuel, but in an enclosed space. American ingenuity began to assert itself, and very soon the internal-combustion engine came into existence. It was not the engine of today—but it worked.

Challenge of a Changing World—Immediately there was a change in the petroleum industry. This did not occur overnight, but, in comparison to the 97 years since 1859, it was rather fast. Whereas kerosine had been the paying product of the industry, a market for gasoline had come into existence—the automobile industry had been born. The automobile industry and the petroleum industry have gone along together ever since.

Inevitably the government became interested, and for mutual advantage in regard to what might be called protection, and also control, the American Petroleum Institute was formed in 1919. All phases of the oil industry were included. Various committees were formed, among them a committee on oil polution.

Problem Recognized—In 1924 the federal government enacted a law aimed at correcting oil pollution. It had very little effect. The trouble continued and increased. In 1925 another survey was to be conducted in order to see if the 1924 law had accomplished anything.

The API stepped into the discussion and requested that it be permitted to carry out this survey and was granted the opportunity. The report was presented in 1928 stated in simple, forceful words that oil polution was serious, widespread, and increasing in its damage and that a committee of technical people should be set up to cope with it.

Committee Formed—A waste-disposal committee was established in the Institute and held an organization meeting in 1929. The fight against pollution was under way. In 1930 the Institute had grown to such size that it was divided into divisions for production, refining and marketing. Each division had its own waste-disposal committee which acted practically independently. The Committee on Disposal of Refinery Wastes in the Division of Refining is still going strong.

This committee really got down to work in 1932. Pollution by oil was a hot subject at the time, and it directed its efforts toward prevention of oil pollution.

API Separator Developed—The original Committee on Disposal of Refinery Wastes, (CDRW), was composed of about 15 members, all from refining companies and originating from all sections of the country. A number of the members had taken part in the 1927 survey, had seen a lot of refinery separators, and had come to the conclusion that they were not much good. Therefore, it was the general consensus that separators should be studied and a good, economical design devised. The first question asked was "What are we shooting for; how much oil can be allowed in the effluent from the separator?" The whole examination resulted in a figure of 30 ppm, and this figure stood up countrywide for a number of years, and still is accepted today in a number of states.

Only a very few separators had been found which would meet this figure, so the need for more effective design still held. The principal effort was directed toward obtaining sinuous flow through the separator so that the oil would have a chance to separate and float, after which it could be collected and retained. Finally, it was decided that the committee would request an appropriation of $6000 from the industry for the study of separating devices, from which study, it was hoped, an effective design could be developed. The appropriation was granted and the money made available.

The first suggestion to come from the committee and bring about improved conditions was that the openings under any baffle wall be made as great as possible in area so as to create as little turbulence as possible. The investigation of separators, and the examination of the principles on which they operated, was continued. After about two years, a report was made to the committee which included a recommended design. Advantage was taken, in the design, of all that had been learned from the hydraulic-laboratory reports and from sewage-treatment plants. It made up practically all of Section I, *Manual on Disposal of Refinery Wastes*.

About 1945, however, the war being over, action picked up at an even greater rate than before. Some refineries had continued investigations on their own. Separators based upon the so-called API design had been put on paper and the cost of building them estimated. There

was a hue and cry to the effect that they were too expensive. The result of this was that another, and larger, sum of money was collected, and a study was started in the experimental engineering laboratory of the University of Wisconsin to determine how effectiveness could be increased and cost of construction reduced.

The University of Wisconsin study finally was completed and reported. It made only two significant design changes. The separator was cut to a single, but larger, section, and a horizontal strip-type distributor was used instead of a head-loss weir. Certain other refinements were eliminated. This design now is included in Section I of the API *Manual on Disposal of Refinery Wastes,* which has been revised several times since its first appearance.

Method Developed—As mentioned, 30 ppm of oil became generally acceptable in separator effluents. There arose early the question: How do we know how much oil we have in the effluent?

At that time the CDRW recommendation for oil determination involved sampling the intake-water supply and the effluent flow and determining the so-called "oil" in each. Actually, the ether extraction method was determining total either-soluble organic matter. Also, evident was the need for a new procedure for determining oil in refinery effluents.

The desire was to deal only with the effluent. A sort of U-tube was devised, in which the ether extract could be evaporated and the oil transferred into a capillary measuring tube where the final evaporation took place and the volume of oil could be measured. The procedure was not perfect; some oil still was lost during the evaporation of the solvent. However, it was a great improvement over that being used rather generally.

Simulation Test—Another procedure developed by CDRW was for determination of the susceptibility of refinery wastes to the separation of the oil content. It is a simple procedure and simulates, as nearly as possible, what goes on in a separator. But it does reveal whether the separator will do any good or not or whether other means of waste treatment should be used.

Acids and Alkalies, Dissolved Solids—The first work done in connection with solutes was on acids and alkalies. Methods for effective lime neutralization were devised, only to realize that such a procedure would build up total dissolved solids and set up adverse osmotic conditions in fresh-water streams. This problem of excessive dissolved solids remains.

Test Specimen Selected—A biological and limnological study was instituted which lasted for about 10 years and in the course of which researches were sponsored to find an organism which would serve as a test organism among the bacteria, the invertebrate level, for which Daphnia were used, and fish, as representatives of vertebrate forms. Procedures also were developed for making the tests.

The Daphnia work of Dr. Bertyl G. Anderson was acceptable for the invertebrate level of the animal kingdom, and the procedure using a restricted list of fish species was acceptable for the vertebrate forms.

Procedure Developed—One of the important actions taken by the committee in connection with evaluation of water quality in streams used for waste disposal was the sponsoring of work by the limnological department of the Academy of Natural Sciences in Philadelphia, under the direction of Dr. Ruth Patrick. The work involved was the development of procedures for the biological survey of streams.

Instrument Standardized—Paralleling the development of the biological stream survey was the work on standardizing the Catherwood diatometer. The diatometer, a small piece of equipment for the capture of diatoms (microscopic plants), was developed at the Academy of Natural Sciences with the aid of a grant from the Catherwood Foundation. The standardization of the instrument, i.e., the determination of the nature of diatom populations in fresh, brackish, estuary, or river waters, was financed by the petroleum industry through CDRW in the Institute. The use of the diatometer is rapidly becoming quite general over many areas of the country and by some of the largest industrial organizations.

Procedures Published—Various members of the committee, working in a group and with other industrial organizations, found a method which would determine phenol and phenol-like substances in much lower concentrations than before. Other analytical methods also were developed.

The complexities of industrial waste analyses prompted the publication of a volume, to be included in the *Manual on Disposal of Refinery Wastes,* on the subject of sampling and analysis.

Importance of Air Pollution—Atmospheric pollution has not been neglected. At present it is one of the most important, if not the most important, subject being considered. It is a difficult subject; streams are a phase of water, which is limited by banks in its movements. The atmosphere is different; it is gaseous, and there is no natural boundary to restrain its movements.

The ideas which have been most completely pursued have been those concerning either complete combustion to naturally existing substances or completely closed systems leading to collection points where the gases or vapors can be used or destroyed. For example, hydrogen sulfide is being converted to sulfuric acid or elemental sulfur. Petroleum vapors are conducted to a torch and burned. Atmospheric pollution is, completely and entirely, a subject for the present.

In Retrospect—The CDRW needs to take off its hat to no one in connection with the treatment and disposal

Meet the Author

W. B. HART joined The Atlantic Refining Company in 1923, eventually reaching the position of superintendent of services at the company's Philadelphia refinery, and holding that position until his retirement in 1955. Before joining Atlantic, Dr. Hart was with E. I. du Pont de Nemours and Company, Inc., for eight years. He attended the University of Pennsylvania and was graduated with B.S., Phar.C. and Phar.D. degrees.

of refinery wastes. CDRW has been influential in molding the thinking of many people in pollution-abatement work and has also given unstintingly of its know-how in solving pollution-abatement problems.

Original presentation at Waste Disposal Session, Twenty-First Midyear Meeting, API Division of Refining, Montreal, May 16, 1956.

More about waste disposal problems . . .

Air-oxidation process: A process has been developed which makes possible the disposal of sulfide-bearing waters without objectionable pollution of either the atmosphere or surface waters. The process involves conversion of sulfides to thiosulfates at elevated temperatures and pressures. Three units are now in operation at Shell's Wilmington (California) refinery and oxidize both process waters and caustic solutions which contain up to 50,000 ppm of sulfides. In each unit the sulfide concentration can be reduced to less than 1 ppm. The largest of the three units was converted from steam stripping to air oxidation at relatively low cost. Operation of these units is discussed and a brief summary of the process variables is presented.

("Air Oxidation of Sulfides in Process Waters and Caustic Solutions," A. G. Smith, Shell Oil Company, Wilmington, Calif.)

Waste Phenol Oxidation: Control of water-borne pollution of the international waterways, between Canada and the U. S., is vested in the International Joint Commission. This group specifies objectives for water quality especially in respect to phenolic compounds. In order to comply with these objectives, the Canadian refineries in the Sarnia, Ont., area have chosen biological oxidation of wastes as an economical method of disposal. Feed preparation by flue gas and steam stripping is essential for good operation in a biological system. Adequate storage capacity for feed is another requisite. Plant operations for three refineries are described.

("Biological Oxidation of Petroleum Phenolic Waste Waters," Alan A. Sheppard, William K. Ross, and Alex D. McRae, Imperial Oil Limited, Sarnia, Ont., Canada.)

The Diatometer: The results of our numerous river surveys have shown that diatoms are one of the most reliable groups for indicating river conditions. They are also very easy to collect and process for study.

As a result of considerable research it was found that the structure of a natural population corresponded to a truncated normal curve. The effect of pollution was to lengthen or put a "tail" on the curve, lower the height of the mode, and reduce the number of species in the total population.

The first research work was done on rivers. The work done under a grant from the API on the Atlantic and Gulf coasts shows that the shape of the curve in natural waters and the effect of pollution on the shape of the curve is, in general, the same in bays, estuaries, and ship channels as it is in rivers. The main differences lie in the fact that the height of the mode is between 19 and 22 species rather than 20 and 26 species as found in rivers. Likewise the number of species in the total population is a little less.

The result of these studies have shown that the diatometer is useful in coastal waters not only to determine the effect of the wastes of a given plant, but also to determine the over-all pattern of pollution of a bay.

("The Diatometer-A method for Indicating the Conditions of Aquatic Life," Ruth Patrick and Matthew H. Hohn, Academy of Natural Sciences of Philadelphia.)

Pollution Control: A new process revision to the water supply and waste disposal system has been installed at Sun Oil Company's Toledo, Ohio, refinery. The new system embodies comprehensive pollution control of all plant waste waters, maximum reclamation of spent waters for re-use within the refinery with minimum pretreatment, and a virtually unlimited supply for emergency fire protection.

Waste treatment is accompanied by selective segregation of waste waters at their source, with no treatment other than removal of oil and settle-able solids in conventional API separators, followed by 5-to-8 day retention in an impounding basin for equalizing and initial biological treatment. Biological oxidation of contaminated waters is completed in plant cooling towers.

This new installation was divided into two phases:

1. Installation of a flue gas stripping tower for removal of sulfides in the process waters to be re-used.

2. Segregating low-alkalinity process waste waters together with storm water from ground runoff.

Approximately 1500 gallons per minute of these waters are available for re-use as cooling tower make-up following retention in the separators and impounding basin.

High-alkalinity waste waters, not suitable for re-use, are collected in a separate system and discharged after oil removal. The impounding basin also serves as a reservoir for emergency storage for fire-fighting water. This supply is virtually inexhaustible, inasmuch as fire water used in the plant can be returned to the impounding basin via the storm sewer system.

Biological oxidation of waste waters during re-use in cooling tower systems has consistently reduced phenols in excess of 99 percent, and chemical oxygen demand has been substantially lowered. There have been no adverse effects on heat transfer efficiency or on corrosion rates in the tubular cooling equipment.

The entire program represents a new approach to the multiple problems of refinery pollution abatement, water supply, and fire protection.

("Biological Oxidation and Re-Use of Refinery Waste Water for Pollution Control and Water Conservation," Harold F. Elkin, Sun Oil Co., Philadelphia, Penn."

API Waste Disposal Session

Analytical Session

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Trace Analysis Catches Up

From arsenic to zinc, petroleum chemists improve methods for determining trace elements. They are very important in catalyst activity and product quality.

RECENTLY IT HAS BEEN found that certain nonmetallic elements such as chlorine can inhibit the performance of catalysts. Unfortunately, there has been available no accurate and simple method by which very minute quantities of chlorine can be determined in petroleum products. As a result of this, needless losses of higher quality products have been encountered in the refinery.

The method presented here can determine less than one part of chlorine, bromine, or iodine in a million parts of gasoline. Such a determination will enable a refiner to keep his catalysts from contact with this harmful material.

("Spectrophotometric Determination of Chloride, Bromide, and Iodide," F. W. Chapman, Jr., and R. M. Sherwood, The Atlantic Refining Company, Philadelphia.)

Arsenic in Petroleum Distillates: It is well known that arsenic poisons platinum-containing reforming catalysts. Numerous methods have been devised for refining control in the selection of charge stocks for reforming from the standpoint of their arsenic content. Nearly all of these procedures employ prior treatment of the sample to concentrate the arsenic in a form whereby the well-known Gutzeit test can be employed. In the evaluation of these methds, it became apparent that some of them gave results which did not agree with the known arsenic content of standards prepared synthetically from triphenylarsine and arsenic-free naphtha.

Other procedures appeared to lack sufficient sensitivity to be used in pilot-plant work in which it was desired to discriminate between two or more stocks whose arsenic contents were nearly the same. A method was devised which overcomes these shortcomings. It is based upon destructive digestion of the sample with acids and subsequent isolation of the arsenic as the colored complex with mercuric bromide in a paper disc. The intensity of the resulting color is measured with a spectrophotometer using a reflectance attachment.

("The Determination of Trace Amounts of Arsenic in Petroleum Distillates," N. C. Maranowski, R. E. Snyder, and R. O. Clark, Gulf Research and Development Company, Pittsburgh.)

Total Nitrogen in Distillates: The rapidly increasing interest in methods for determining low concentrations of nitrogen in petroleum charge stocks used in catalytic conversion processes is clearly shown by numerous recent publications on this subject. However, very few satisfactory procedures have been developed to cover samples containing less than 30 ppm of nitrogen.

The authors have developed a unique method whereby it is possible to concentrate the nitrogenous impurities from large samples onto a small column of silica gel. This gel is then treated by customary Kjeldahl analytical procedures to determine the amount of such nitrogenous impurities present.

("The Determination of Trace Amounts of Total Nitrogen in Petroleum Distillates," G. R. Bond, Jr., and C. G. Harriz, Houdry Process Corporation, Marcus Hook, Pa.)

Molybdenum and Zinc: An old elemental analysis scheme combined with modern instrumentation gives a convenient, accurate method of analysis. Using the continuous X-ray radiation from a copper X-ray diffraction tube, in combination with a modern commercial X-ray spectrometer, it is possible to make X-ray absorption measurements on materials as a continuous function of monochromatic wave length. By making measurements near and on each side of an absorption edge, a specific analysis for the element characterized by the edge is possible. At the higher concentrations, the method is preferred to X-ray fluorescence because of the absence of a matrix effect. It is not so sensitive as fluorescence at the trace level.

("X-Ray Absorption Edge Spectroscopy as an Analytical Tool—The Determination of Molybdenum and Zinc," R. E. Barieau, California Research Corporation, Richmond, Calif.)

Lead in Gasolines: The poisoning effect of heavy metal ions on platforming catalysts is well known. The increasing use of these catalysts for upgrading gasoline and naphtha has resulted in a need for a rapid and accurate method for the determination of 10 to 100 parts per billion of lead.

Two analytical methods have been developed, both of which are modifications of dithizone colorimetric procedures. One method is a two-color method involving the

use of a spectrophotometer, and the other is essentially a one-color method involving the use of a color comparator. The former is more suitable for use by laboratories with specialized equipment for the simultaneous analysis of a number of samples; the latter may be applied in a refinery or field situation using very simple equipment. The accuracy of each method is 10 parts per billion.

("Determination of Trace Amounts of Lead in Gasolines and Naphthas," M. E. Griffing, Adele Rozek, Ethyl Corporation, Detroit; and L. J. Snyder, S. R. Henderson, Ethyl Corporation, Baton Rouge.)

Water in Methane and Ethanethiol: To prevent pollution of air in refining operations, most oil companies isolate mercaptans and dispose of them. One way of disposal is by selling these materials which are used as odorants in domestic fuel gases and as starting materials in making other useful chemicals. In order to sell mercaptans, however, it is necessary to know their purity. Chemists at Union Oil Company of California have devised a simple, rapid method for determining water content of methyl and ethyl mercaptan.

("Determination of Water in Methane and Ethanethiol," G. Matsuyama, Union Oil Company of California, Brea, Calif.)

Carbon Monoxide in Gaseous Hydrocarbons: Information as to the amounts of carbon monoxide present in gaseous hydrocarbons can be of great importance. The yield of products and the reactivity of catalysts in many petrochemical processes may be materially affected by trace quantities of this contaminant. Suitable analytical procedures do not exist for the determination of a few parts per million carbon monoxide in gaseous hydrocarbons. Generally, either the methods lack sufficient sensitivity, or the hydrocarbons react with the reagents.

A distillation-spectrophotometric method has been successfully applied to the determination of 0-100 ppm carbon monoxide in hydrocarbon gases, with an accuracy of ±1-2 ppm. In this procedure, the carbon monoxide is separated from the interfering hydrocarbons by a low temperature fractional distillation after the addition of methane. The carbon monoxide is then measured using an iodine pentoxide-spectrophotometric technique.

"Determination of Trace Amounts of Carbon Monoxide in Gaseous Hydrocarbons," K. H. Nelson, M. D. Grimes, D. E. Smith and B. J. Heinrich, Phillips Petroleum Company, Bartlesville, Okla.)

Vapor-Phase Chromatography: Analytical chemists are looking toward vapor-phase chromatography as a rapid inexpensive method for determining the composition of natural gas, gasolines, and other products. The paper presents an example of what vapor-phase chromatography will do. The authors report successful separation and analysis of hitherto unidentified trace impurities present in nearly pure materials such as octane number reference fuels.

("The Application of Vapor-Phase Chromatography to the Analysis of Liquid Petroleum Fractions," D. H. Desty and B. H. Whyman, The British Petroleum Company, Ltd., Sunbury-on-Thames, Middlesex, England.)

Organic Disulfides: A new, fast, and simple method for determining disulfides in petroleum products was developed. Disulfide determinations are important in product control, particularly in "sweetening" processes. The new method was tested, together with three older methods, for its reactivity toward disulfides of various structures. It was found to be superior to older methods when applied to disulfides in the gasoline boiling range.

("Quantitative Analysis of Organic Disulfides," R. L. Hubbard, W. E. Haines, J. S. Ball, U. S. Bureau of Mines, Laramie, Wyo.)

Fuel Oil Stability: For the past number of years a considerable amount of research has been conducted to develop a satisfactory method for measuring the storage stability of distillate fuel oils. Several methods have appeared in the literature employing filter pad discoloration, filterability, and actual insoluble determinations by gravimetric procedures.

In this paper a method for determining the insoluble content of an oxidized fuel oil by use of optical density is described. The method consists of optical density measurements employing a 1 cm light path and 500 mu on oxidized oil samples before and after filtration through a fine sintered glass filter (4.5-5 microns). Correlations have been established for determining the insoluble content from the difference in optical density on the filtered and unfiltered samples. Accuracy is equivalent to gravimetric procedures.

("Determination of Fuel Oil Stability by Optical Density Measurements," W. H. Armstrong, D. Milsom, H. P. Hebert, and A. R. Rescorla, Cities Service Research and Development Company, New York.)

Micro Vapor Pressure Method: The precise adjustment of fuel vapor pressure will be made much easier by a newly developed device for measuring it. The new vapor-pressure method has five times the accuracy of the old method, greater speed, and an improved sample handling procedure. This means improved performance for the consumer's equipment and a savings in money to the refiner.

Another big advantage of the new vapor-pressure measuring apparatus is the small amount of sample required to make a measurement. Only one cubic centimeter, which is about 0.034 oz., is needed. The presently used apparatus requires over 130 times this amount.

("A Rapid, Precise Micro Vapor Pressure Method," A. Y. Mottlau, Esso Research and Engineering Company, Products Research Division, Linden, New Jersey.)

Total Sulfur: An improved method, applicable to control procedures, is presented for the determination of sulfur in petroleum samples. This technique permits the analyses of all types of sulfur which might be present in a wide variety of sample materials ranging from low boiling naphthas to high boiling coker gas oils. In general, the sample is aspirated into an oxhydrogen flame of an atomizer burner and burned. As products of combustion are formed, they are swept by air into a hydrogen peroxide scrubber where oxides of sulfur are converted to sulfate. The sulfate formed in the scrubber is then measured by adding an excess of barium acetate and determining the excess barium by an EDTA titration. Samples covering a wide range of concentration from one hundred to several thousand ppm sulfur have been

API Analytical Session

Analytical Session . . .

successfully analyzed without danger of interference from halides or nitrogen in the sample.

("Combustion and EDTA Titrimetric Determination of Total Sulfur in Petroleum Products," O. N. Hinsvark and F. J. O'Hara, The Girdler Company, Louisville, Ky.)

Powdered Solids: A number of rapid precise instrumental techniques have become available for inspection of the materials of petroleum refining. The X-ray fluorescent spectrograph is in the forefront of new instruments for elemental analysis of such materials.

Basically, the X-ray fluorescence spectrograph consists of a high-power X-ray tube—the beam of which causes the elements in a specimen to emit their own characteristic X-rays or to fluoresce—a diffracting device to separate the X-rays into their respective unique wavelengths, and a device to detect and measure each wavelength. The measurement of an element is independent of the manner of chemical combination with other elements but not of their mutual presence in the substance. The elements influence each other in such a way that the intensity of X-rays emitted by a given element is not a direct measure of its concentration. This paper describes a technique for lessening or eliminating this effect so that a number of elements coexisting in a powdered solid can be measured with reasonable accuracy.

("Fluorescent X-Ray Spectral Analysis of Powdered Solids by Matrix Dilution," E. L. Gunn, Humble Oil & Refining Company, Baytown, Texas.)

Calcium or Zinc Additives: Chemists at the Esso Research and Engineering Company have developed a rapid method for determining either calcium or zinc. This can be used to control additive manufacturing plants or the blending of lubricating oils. The procedure consists of a direct titration of the metal in an acetone solution of oil with an organic complexing agent. With this procedure it is possible to complete an analysis in about 20 minutes as compared to 4 hours by conventional methods.

The method has been used successfully to control the manufacture of various additives and the blending of many lubricating oils with additives containing calcium or zinc.

("Determination of Calcium or Zinc Additives in Lubricating Oils and Concentrates by an EDTA Titration Method," P. B. Gerhardt and E. R. Hartmann, Esso Research and Engineering Company, Linden, N. J.) ##

Training Session — Computers vs. Executive Judgment

THE PROBLEM of providing engineers qualified in the field of process engineering and in general refinery technology for the postwar expansion of a multi-plant company is a continuing challenge. One Canadian company has made rapid progress in seven years to augment the skills of engineers drawn from various universities and with differing work experience. A nine-weeks course, conducted annually by senior engineering staff members, has provided the required flow of qualified men into refinery operations.

("Developing Engineers in the Field of Refinery Technology," Dwight S. Simmons, Imperial Oil Limited, Toronto, Ont., Canada.)

Need for Liberal Arts in Executive Development: It is said that candidates for high executive office are now asked, "What can you do that a computer can't?" Even without the rapid development of automation, the key factor in business leadership would still be the breadth and depth of executive judgment.

Champions of the liberal arts have argued that their discipline, rather than any "practical" form of vocational or technical training, is the one sure way to prepare an executive for the arduous tasks of judging values in men.

("The Liberal Arts in Executive Development," J. Roby Kidd, Canadian Association for Adult Education, Toronto, Ont., Canada.)

Supervisory Development: What happens when line managers become responsible for translating training into action? Shell Oil Company found out recently when it conducted an experiment in which line management carried out supervisory training. Particular emphasis was placed on the transition from an introductory program, consisting of conferences covering topics of general value for all levels of superivsion, to more selective programs aimed at the training needs of specific supervisory groups.

The experience of doing this through assigning to individual line managers the responsibility for determining definite training needs was quite worthwhile.

("The Line Manager's Role in Supervisory Development," G. Davidson, Shell Oil Company of Canada, Ltd., Toronto, Ont., Canada.) ##

Instrumentation Session — More Instrumentation Is the Trend

Consider Instrumentation in Design: Instrumentation must be given serious consideration in the initial design of a plant. Instruments and systems currently available for control of a process are a necessary part of present plant operations. The relation of these instruments and systems to product quality measuring devices are being discussed more fully.

There is little doubt that instrumentation will have a significant impact on future plant design. Particular consideration will be given plant control centers, remote tank gaging, automatic data handling, computer control, and many other modern features which have been developed.

("Instrumentation of Refinery Processes," J. G. Kerley, Shell Oil Company, New York, N. Y.)

In-Stream Analyzers: Closer process control is always being sought in the process industry. The advent of process stream analyzers go a long way toward making closer control possible.

In the matter of a few short years we have seen a number of complex laboratory methods of analysis become continuous monitoring and controlling plant instruments. It is interesting to consider some of the typical plant installations of these instruments.

Two of the practical problems which have arisen in using these instruments are: (1) obtaining a continuous representative stream sample, and (2) maintenance. Some of the significant factors which contribute to these problems and possible ways to solve them are being discussed.

("Automatic Process Stream Analyzers," Thomas C. Wherry, Phillips Petroleum Company, Bartlesville, Okla.)

Plant Managers Need Information: The principles of instrumentation apply to management, too. Many of the applications of instrumentation in a modern chemical plant are limited to the simplest unit functions. The technical staff in these plants, which is responsible for the over-all product quality, yields, and efficiencies, does not get current information soon enough nor accurately enough to provide effective closed loop control. Plant management is even worse off in this respect.

Given modern information handling equipment, combined with both analog and digital computer, management will find it possible to provide true closed loop control of the most complex processes.

("Information for Plant Management," Albert F. Sperry, Panellit, Inc., Skokie, Ill.)

The ISA Serves Our Industry: A well organized society is required to serve the men in this growing field of instrumentation. The increase emphasis on automation is sure to draw more people into this field, making the demands for a society even greater.

The Instrument Society of America was founded in 1946 to furnish just such a society. Today there are 84 sections of the Society in the U. S. and Canada. The Society is sponsoring programs in many fields. Some of these are: control in the process industries, control in the fabrication of metals and electronics, nuclear instrumentation, and transportation instrumentation.

The Society also holds conferences, presents exhibits, and creates committees required to keep members well informed.

("Service of the ISA to the Petroleum Industry," Robert T. Sheen, Instrument Society of America, Philadelphia, Pa.) ##

Fuel & Lubricants Session — Feeding Problems of Future

WHAT ARE THE methods used by the automotive engineer in bringing out future engines? Normally, the engines are designed to fit the fuels forecast for availability in the service stations at the time of new car model introduction. This normal method of design has now been interrupted by three new factors: (1) the advent of new type gasolines made possible by catalytic cracking and reforming, (2) the advanced designs of the automotive stylist, and (3) the demands of the public for more performance. At this time it appears that the latter two factors will be governing.

Comments were made on the effect of these influencing factors on the characteristics of the fuels of the future, as well as suggested methods of use.

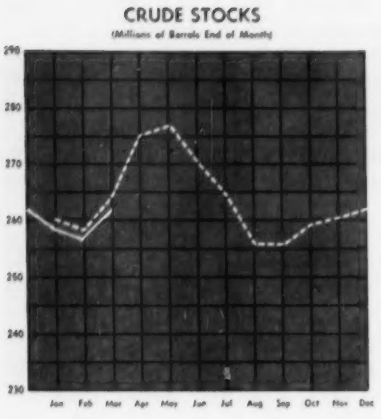
("Feeding Problems of the Future Engines," A. E. Cleveland and R. I. Potter, Ford Motor Company, Dearborn, Michigan.)

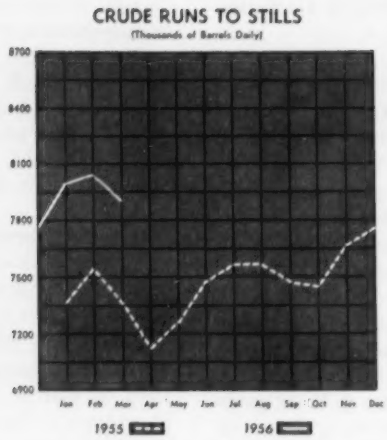
Road Performance: As new processing methods are being used by refiners to produce gasolines of higher and higher antiknock quality, the incentive for maximizing road antiknock performance for a given laboratory specification continues to increase. This discussion illustrates the use of statistical design as a means of making such a program feasible for any refiner. It further presents the fuel behavior data and blending generalizations as determined for the refining operation specifically studied. The comparison available between results from the comprehensive program and those from the factorial experiment shows that defining optimum road performance for a given research specification is a reasonable objective for an individual refinery.

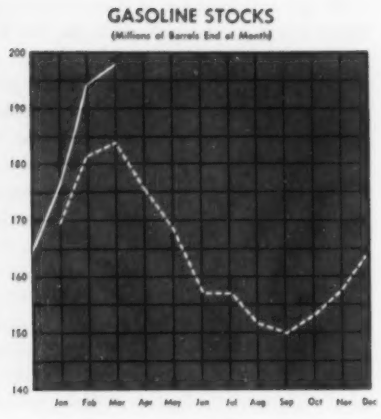
("Practical Design of Better Fuels—A Statistical Approach to Road Performance Studies," F. D. Buerstetta and W. C. Healy, Jr., Ethyl Corporation, Detroit; and E. E. Sorenson and W. J. McGuire, The British American Oil Company, Toronto, Ontario.)

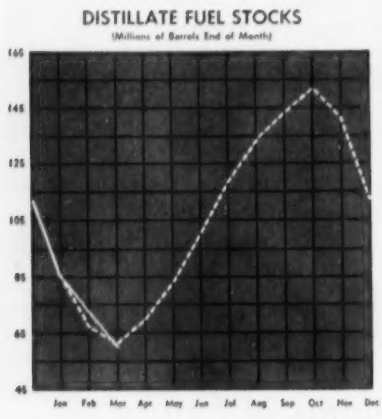
Chamber Deposits: A study of the combustion-chamber deposit problem with reference to both knock and surface ignition has been made in high compression ratio engines with particular emphasis on the effect of compression ratio, combustion-chamber design, fuel type, and lubricant type. Both laboratory multicylinder engines and road-test cars were used to study the combustion process within the engine. Four different types of engines with compression ratios as high as 11:1 were used, and tests were made using a variety of fuels and lubricants. The results of this investigation indicate the magnitude of the combustion-chamber deposit problem in the engines of tomorrow and also suggest some desirable attributes of fuels and lubricants for these engines.

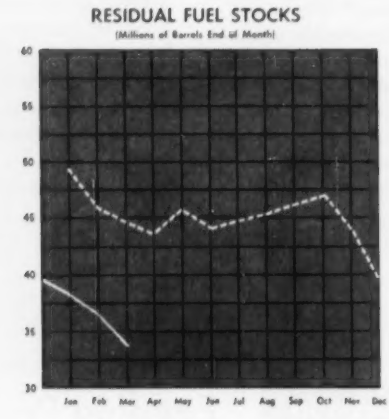
("The Combustion Chamber Deposit Problem in High Compression Ratio Engines," E. I. du Pont de Nemours and Company, Wilmington, Delaware.) ##

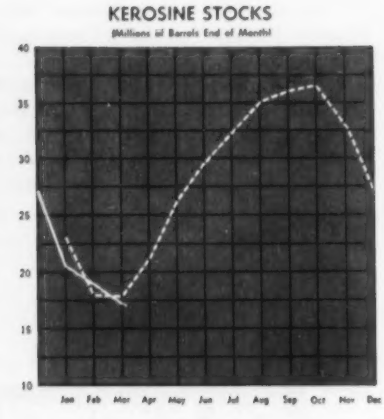












Taking Stock

Cecil W. Smith
Economics Editor

- Gasoline stocks hit all-time high
- Refining rates cut substantially
- Crude imports ease after new peak

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1954:													
March	6,507	6,923	271,867	3,375	181,297	353	17,533	1,458	60,270	1,168	44,249	654	1,088
April	6,615	6,811	280,310	3,404	177,006	322	19,656	1,374	61,721	1,140	44,362	574	950
May	6,471	7,038	282,250	3,482	177,606	302	23,892	1,372	73,581	1,148	47,009	708	1,021
June	6,500	6,947	285,155	3,483	165,404	306	28,184	1,399	86,325	1,123	50,216	624	999
July	6,242	6,916	284,894	3,480	158,010	295	31,953	1,416	101,657	1,089	54,365	724	1,038
August	6,168	6,862	281,043	3,492	153,168	302	34,949	1,453	117,579	1,069	56,332	664	966
September	6,151	6,939	274,608	3,511	150,916	301	37,099	1,514	128,061	1,086	56,702	672	999
October	6,135	6,834	269,442	3,457	149,661	310	37,140	1,545	139,128	1,066	56,541	642	1,065
November	6,346	6,975	264,566	3,530	150,604	354	34,547	1,622	133,886	1,120	54,891	636	1,104
December	6,394	7,238	258,385	3,605	155,400	381	27,826	1,668	108,144	1,187	52,105	729	1,301
1955:													
January	6,761	7,379	260,156	3,639	169,562	409	23,266	1,740	86,692	1,235	49,457	739	1,348
February	6,835	7,549	258,630	3,655	181,643	374	18,291	1,847	68,513	1,239	46,042	751	1,379
March	6,886	7,374	264,430	3,543	183,972	357	18,187	1,703	62,457	1,185	44,970	742	1,319
April	6,887	7,136	275,232	3,502	175,601	312	21,486	1,534	70,139	1,110	43,838	697	1,123
May	6,677	7,281	276,948	3,605	168,751	296	26,375	1,519	83,559	1,111	45,083	742	1,137
June	6,613	7,484	270,850	3,725	157,439	269	29,830	1,628	100,652	1,080	44,398	764	1,159
July	6,632	7,580	264,601	3,824	157,079	286	32,749	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3,784	150,194	279	36,361	1,621	143,248	1,061	46,267	829	1,218
October	6,837	7,465	267,346	3,827	153,103	309	36,705	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	341	33,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,117	8,045	256,964	3,726	194,474	380	18,582	1,939	72,414	1,285	36,388	842	1,364
March	7,157	7,907	262,066	3,711	198,082	354	17,377	1,818	62,330	1,221	33,718	948	1,342
Week Ended:													
4–20–56	7,130	7,436	270,708	3,514	192,933	292	18,070	1,712	61,926	1,169	32,829	788	1,243
4–22–55	6,832	7,089	272,781	3,425	179,741	321	20,429	1,483	65,678	1,144	44,619	596	996

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

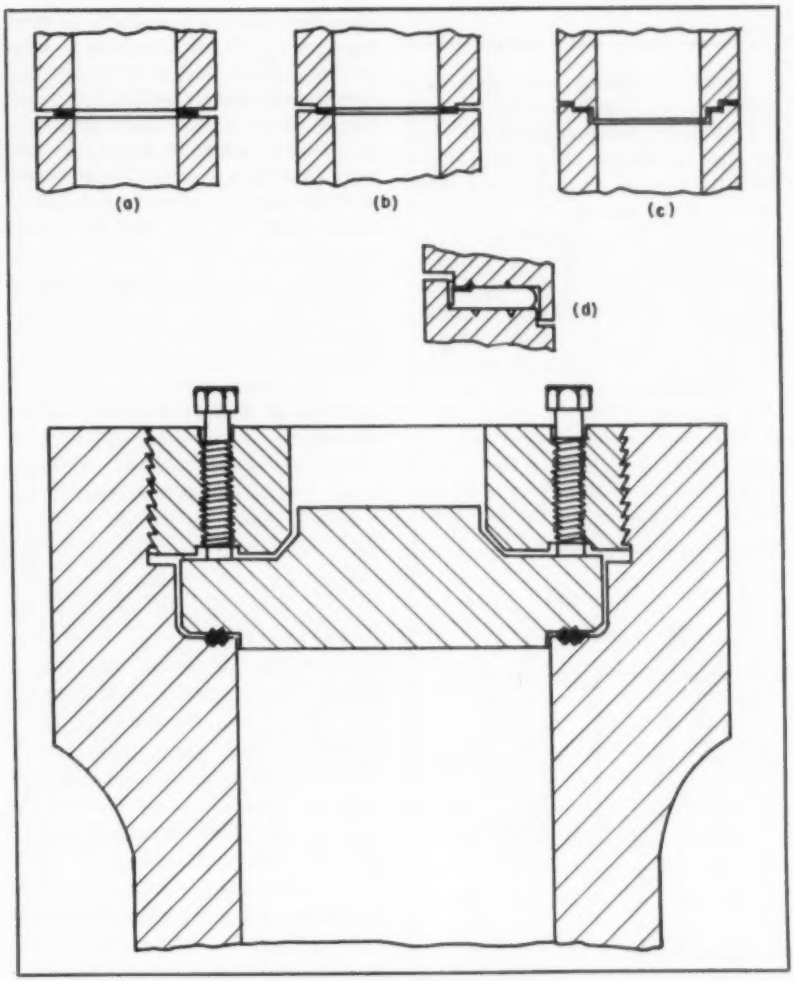


FIGURE 1—Flat gasket joint (a) non-retained; (b) partly retained; (c) fully retained; (d) fully retained with grooves.

Holding High-Pressure Joints

Here's a review of the types of closures in use . . . and where each works best . . . why . . . and its relative cost.

Walter Coopey, Consultant, Charleston, W. Va.

DESIGNING HIGH-PRESSURE joints not only involves first cost but also maintenance and operating costs. The latter might be the most important.

Interruptions in operation which cause loss of production are not as a rule considered as maintenance costs. There is no reason why they shouldn't be. If they were, more emphasis would be placed upon the importance of specifying trouble free equipment in order to obtain long continuity of operation. This is important both as to production cost and perhaps quality of the product.

While there are numerous designs of joints and closures for high pressure tubing and vessels, the basic designs are few. The following descriptions cover some of these with which the author has had experience.

Flat Gasket Joint—(Figure 1). This is the most elementary type of joint and is widely used. But it is, also, frequently misused. There are three methods of applying gaskets as shown in the sketches—(a) non-retained (b) partly retained and (c) fully retained.

In high-pressure work a non-retained gasket should never be used because it is susceptible to being blown out and has other disadvantages which will be made apparent later. The partly retained gasket is often used and, although it may give satisfactory performance in some applications, it should be avoided if there are changing temperature conditions.

Assuming that only metallic gaskets are under consideration; in the selection of materials, the properties of coefficient of expansion, ductility, and resistance to corrosion are usually reviewed with one being overlooked. This is the thermal conductivity of the metal. The importance of this can best be shown by reference to a table giving a comparsion of this property with the coefficient of expansion for a number of the common metals.

Metal	Relative Thermal Conductivities	10,000 x coef. of linear expansion per F.
Silver	240	0.107
Copper	220	0.109
Aluminum	119	0.128
Tin	35	0.124
Iron (Wrought)	35	0.065
Nickel	34	0.071
Steel (1% C)	26	0.067
Lead	20	0.162
Everdur	19	0.095
Stainless Steel (18-8)	10	0.080

Although silver is used in special applications, the common gasket materials are copper, aluminum, steel and stainless steel. Aluminum and most of its alloys should be avoided for temperatures approaching 400 F. because they soften and will extrude under pressure through very small clearances. A difficulty with stainless steel is its work hardening property.

It was observed in the early operation of ammonia synthesis processes at pressures from 5000 to 15,000

pounds per square inch that leaks invariably occured at gasket joints if for some reason there was a quick temperature drop in the hot lines of the system. The drop might only be a matter of 20 F. The joints were partly retained as shown in (b) and the gasket material copper. It was found that the leakage could be controlled if the temperature change could be effected slowly which indicated that differences in the properties of the gasket material and tubing might be responsible.

Because there is a ratio of 9 to 1 in the thermal conductivities of copper and steel, it was concluded that the copper contracted more quickly than the steel tubing due to temperature drop and leakage resulted. When metal jacketed asbestos gaskets, as shown in the enlarged section (d), were substituted for the copper gaskets, the trouble was remedied. The metal sheath is about 0.010 thick soft steel.

The gasket is relatively cheap and readily conforms to the seats in the tubing. The gasket grooves, 1/64 inch deep with a 60-degree included angle are of appreciable value and should be used in any flat gasket application.

There is nothing new about the fully retained joint shown in (c) as it was used by Amagat about 90 years ago for pressures up to 45,000 psi. It is the best of the flat gasket joints and is preferable to the tongue and groove type. Not only does it fully retain the gasket but it protects it from fluid and temperature effects. Copper and other high conductivity gasket materials will be satisfactory because the rate of contraction change, due to temperature, will be the same as it is with the tubing.

The large vessel closure, shown in the sketch, was developed in the early 1920's by the Fixed Nitrogen Research Laboratory for the converters of a 5000 psi ammonia synthesis system. In this design the gasket is partly retained and pressure is exerted upon it by the large jack bolts in the ring above the head. The threads in the ring and the head are the buttress type and are interrupted so that the ring can be inserted by a partial turn. While this joint is used on experimental size units, it is not recommended for large vessels in commercial installations. In many cases it has been replaced by the Delta joint which will be described later.

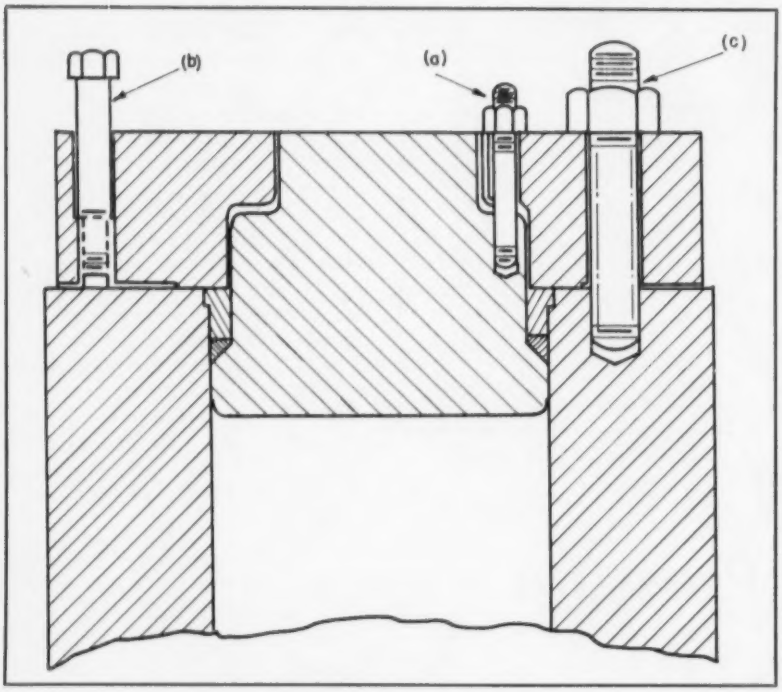


FIGURE 2—Bridgman Joint.

Flat gasket joints of the type (d) have been used successfully at pressures to 12,000 psi on tubing as large as 2½ inches inside diameter and would undoubtedly be satisfactory on larger sizes at still high pressures. Very often joints of the Lens Ring type have been specified for relatively low pressures when a flat gasket would have cost less and been more trouble free.

There is a point which should be emphasized in the use of gasketed joints and it applies to all types of joints and closures. There is practically no joint that will give maximum satisfaction if there is indiscriminate tightening of the bolts which apply pressure to the gasket. Although there may be minor variations in the way it is done, the sequence used in performing this operation is important for best results.

First, bolts should be taken up lightly to obtain contact of the joining faces before actual tightening is started. Then opposite (180 degrees) bolts should be tightened not over ¼ turn and this be done to the rest of the bolts, advancing 90 degrees clockwise. By following this procedure the gasket and bolts are uniformly stressed. When indiscriminate tightening is done, it is not uncommon to experience difficulty in taking a joint apart even to the extent that threads are stripped and bolts twisted off.

Bridgman Joint—(Figure 2). This is one of the first, if not the first, of self sealing joints based upon the unsupported area principle. It was developed by Dr. P. W. Bridgman and has been used by him in his high pressure investigations at pressures many times higher than anything now in commercial operation. The evolution of the joint is described in Dr. Bridgman's book, The Physics of High Pressure, which is an invaluable reference for anyone interested in high pressure work. The writer has had experience with this joint since 1929 and does not know of a single case of leakage where it has been properly installed.

As shown in the sketch, the pressure load is sustained by a large ring bolted to the top of the vessel. To obtain fluid tightness the floating head

is pulled up against the triangular shaped gasket by bolts (a) to get initial sealing and then the pressure takes over. The higher the pressure, the tighter the sealing effect. To remove the head, the jack bolts (b) are forced down against the top of the vessel after the nuts are taken from the large bolts. Any of the ductile metals can be used for the gasket; depending upon the process fluids being handled.

Although not generally used for tubing, the joint has been applied to the heads of large vessels in commercial operations as well as to experimental installations. There are many modifications and applications of the principle of the design; one of the most recent being a patented seal for the bonnets of high pressure valves.

The chief drawbacks to this closure are the high initial cost; a tendency for the gasket seating surface at the wall of the vessel to become depressed in time and to require remachining; and the difficulty of adapting it to existing equipment. In spite of these, it is an excellent joint.

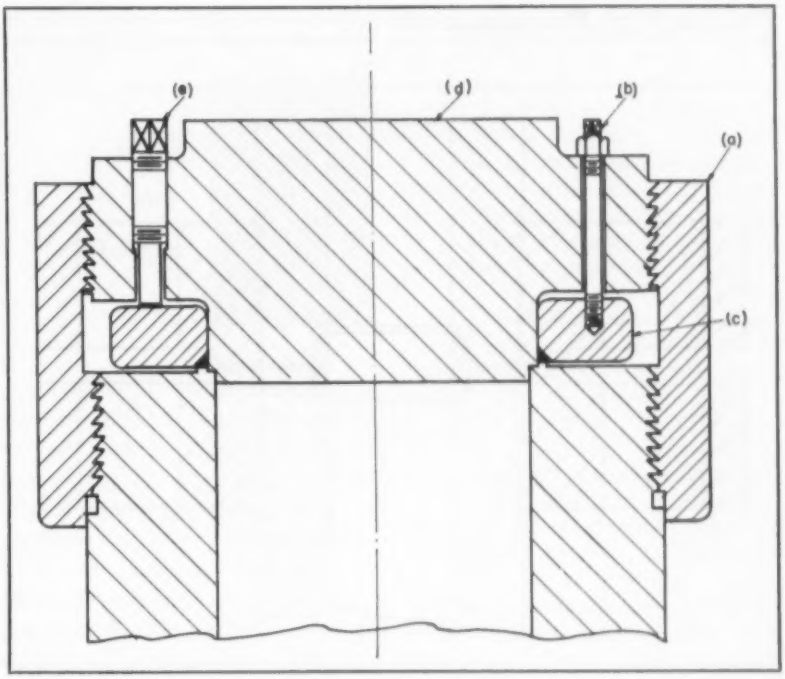


FIGURE 3—Casale Joint.

Casale Joint—(Figure 3). The first small scale converters for the Casale ammonia process had flat gaskets but when 24 inch inside diameter units, rated at 30 tons per day, were installed in this country in 1929, a better closure of the design shown was used. The flat gasket joint had been unsatisfactory.

To install, the sleeve (a) is screwed on the top of the vessel and only rarely needs to be removed. Bolts (b) suspend the jack ring (c) from the head (d) which is put in place through an interrupted thread arrangement. Tightness is obtained by turning down on the jack bolts (e) gradually and in proper sequence. The internal pressure load is taken entirely by the sleeve (a) and the triangular gasket simply prevents leakage from occurring between the head and the shell of the vessel.

Care must be used in the selection of the materials of the various parts, particularly of the jack ring (c). This can be fractured if too hard a material is provided. The gasket is usually copper. While there may be a similarity to the Flat Gasket Joint, Figure 1, the Casale Joint is a much better design and has given satisfactory service at 12,000 psi.

It is a high initial cost closure and can not be readily adapted to existing equipment.

Lens Ring Joint—(Figure 4). This is the most common joint used for high pressure tubing and apparently originated in Germany about 1920 in connection with synthetic ammonia synthesis. The design is based on the unsupported area or self sealing principle. Although there are many adaptations of the design, the one shown in (a) seems to have some preference.

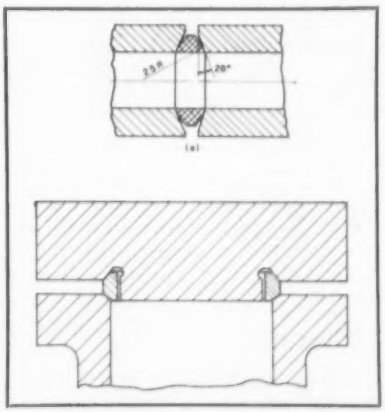


FIGURE 4—Lens Ring Joint.

This consists of a lens shaped ring of a low alloy steel heat treated for a higher hardness than the tubing. The ends of the tubing have conical surfaces and the ring receives no radial support. The objective is to obtain line contact of the seating surfaces and the line should be as close as possible to the inner edge of the tubing to get the maximum unsupported area effect.

Much of the trouble experienced with this joint has been due to nonuniform take up of the flange bolts and to the erroneous idea that some misalignment of the tubing is permissible because the lens surfaces of the ring are sections of a conical ball. If the flanges are not parallel, uneven strain is put upon the bolts which becomes magnified under operating conditions.

The result is leakage. When this happens and further tightening is resorted to, almost full face contact results and most of the unbalanced pressure effect is lost. The joint then approaches being a metal to metal one. There is no substitute for uniform take up and good alignment. Attempts have been made to compensate for poor application with bellows forms of rings but generally they have served no useful purpose

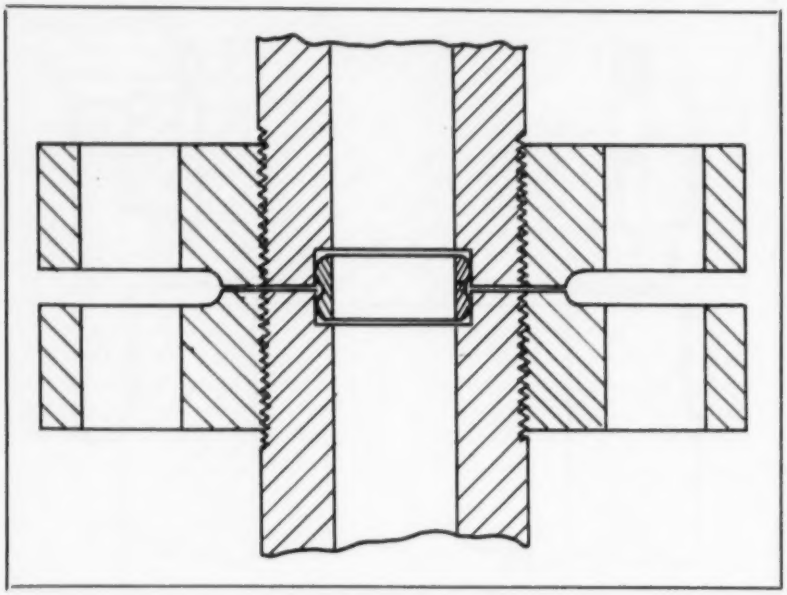


FIGURE 5—Wave Ring Joint.

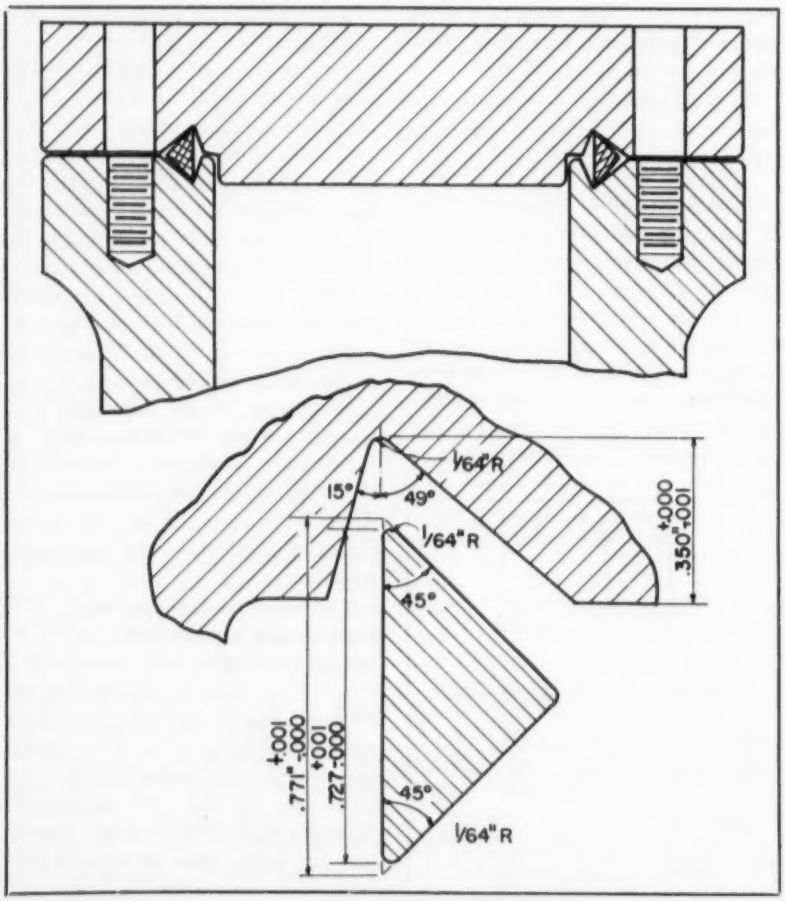


FIGURE 6—Coopey Delta Joint.

because they, too, can be misapplied, and usually are.

In many cases where the lens ring joint has been installed it would have been cheaper and better to have used the fully retained flat gasket joint. In very small sizes the cup and cone joint with metal to metal contact is better than either.

The large sketch shows a patented design of the joint adapted to large vessels. Sometimes, for better results, the face of the ring is sheathed with either copper or aluminum. Because the ring is exposed directly to the system fluids, the material of which it is made is usually steel or stainless steel.

Wave Ring Joint—(Figure 5). This is a patented self sealing joint based on the unsupported area principle which was developed about 1932 by W. R. D. Manning and assigned to the Imperial Chemical Industries, England. As shown in the sketch, the ends of the tubes have cylindrical sockets and the ring has a double convex outer surface of wave form. The joint takes its name from this.

The ring is made of a harder material than the tubing and the crests of the wave are slightly larger in diameter than the sockets forming the seats. Initial contact pressure is obtained when the ring is forced into the sockets and then in service the unbalanced pressure across the unsupported area of the ring keeps the joint tight.

The construction calls for precision workmanship and careful handling. Although the joint served a useful purpose in the development of a high-pressure process, it has never been widely accepted because of its limitations. It can not be considered practical for commercial plant operations.

Coopey Delta Joint—(Figure 6). This joint was originated by the author in 1938 primarily to overcome difficulties being experienced with flat gasket joints on large vessels in 12,000 psi service. It is a self sealing type on the unsupported area principle and might be considered a composite of the best features of some of the other joints.

As shown, the gasket is triangular in section and is slightly wider than the combined depth of the gasket grooves. Initial sealing is obtained at the edges of the gasket when the head bolts are tightened lightly and in operation the full face of the gasket is subjected to the internal pressure in the vessel.

The first test of the joint was made in the packing section of a compressor where there was a pressure range of 5000 to 13,000 psi. Flat gaskets had been used to seal between the packing sections or retainers and leaks were of frequent occurrence. Grooves were cut into the flat gasket seats for the triangular gasket which was made of copper. Good results were obtained until leakage occurred after 3 million pressure cycles.

Inspection showed that the gasket had failed from fatigue. It was concluded that, because they have relatively small sections, unsupported area gaskets should not be used in alternating pressure service unless the stress range is low. In other respects the performance was considered excellent because the test demonstrated that the principle of the joint was sound for static pressures.

The next test was made on an 18-inch ID vessel with flat gaskets in 12,000 psi service where trouble was being encountered. Grooves were cut in the flat gasket seats with the dimensions shown in the enlarged section of Figure 6. The results were as expected and no further changes in design were required. In fact, although formulas have since been developed, the design is so flexible that gaskets with these same dimensions have been used for a range of pressures from 2500 to 30,000 psi for vessels with diameters from 6 inches to 36 inches.

Since 1949 the joint, which is not patented, has been public property and has been used rather extensively. Because the gasket can be protected from the contained fluids, any of the high conductivity metals are satisfactory. Low carbon steel, silver, copper, aluminum and stainless steel have all been used in various applications.

Although intended primarily for vessels, the joint, with a gasket of small cross section has been tested on 7/8-inch ID tubing at 12,000 psi with satisfactory results. But for this purpose a fully retained flat gasket joint is just as good and will cost less. However, there is no reason why the Delta joint can not be used in any application where the Lens joint has customarily been employed and give as good, or better, results.

As with any high-pressure equipment, care must be exercised in applying the joint. The seating surfaces should be well finished, about 15 micro-inches, and be kept clean. It is simple; it is economical with respect to machining costs; it is self sealing which makes severe tightening of bolts unnecessary; it permits the use of larger bolts; it is adaptable to high pressures and high temperatures; and it can be used under corrosive conditions.

The Delta joint has given satisfaction on converters, autoclaves, separators, heat exchangers and even between sections of plastic extruders where flat gaskets leaked. It is easily substituted for any flat gasket joint.

"O" Ring Joint—This has been applied chiefly in small diameters and in low temperature service. Some of the limitations with respect to fluids and temperature have been overcome by improvements in the synthetic rubber like materials with better solvent and heat resistance.

If special care is taken in the joint design to prevent extrusion, it is good for much higher pressures than shown in catalogs. The possibilities of the joint have not been fully explored.

Metal to Metal Joint—Where additional care and expense is justified, this joint can be the answer to some difficult problems although its use is restricted to relatively small diameters. Depending upon circumstances, the mating surfaces may either have line contact or be lapped to fit. Because there is no flexibility, extreme care should be used in making up this joint.

Without knowing the conditions of service such as—pressure level (static or dynamic); temperature and temperature range; corrosiveness of the contained fluids; size of the tubing or vessel; and the frequency with which the joint must be broken, it is difficult to satisfactorily specify a definite type of joint or closure. There have often been misapplications of joints because of lack of appreciation of these factors and in some cases the joint may be inadequate for the purpose and in others unnecessarily expensive.

Where there are long runs of tubing, the best joint is a welded one. Good welding can now be obtained for practically any material that can be drawn into tubing. Welding should not, however, be used where there are alternating stress conditions because even a minute flaw can be a point of high stress concentration which will promote a fatigue failure. Fortunately, in most high pressure processes the rate and magnitude of pressure change in pipe lines and vessels is so small as to be insignificant. The problem is quite different with the equipment used to develop the pressure such as pumps and compressors.

It is probably worth emphasizing again that, whatever the design of joint or closure, it should not be thrown together. Care in the installation and in applying pressure to the gasket will pay dividends. ##

Meet the Author

WALTER COOPEY, who for the past six years has been doing private consulting work in Charleston, W. Va., served 33 years with E. I. du Pont de Nemours & Company as development engineer, engineering manager and consultant. Starting with ammonia synthesis in 1925, he engaged in the development of a wide variety of processes based on high pressure technique involving pressures up to 35,000 psi. He is a graduate of Pennsylvania State University with a degree in mechanical engineering.

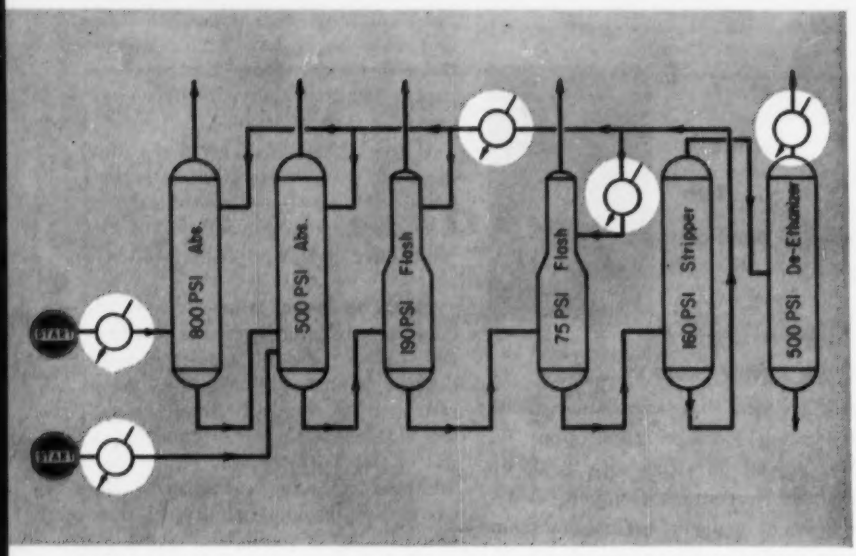


FIGURE 1—This flow diagram for Plant No. 1 shows the coolers which are furnished with the iso-butane refrigerant.

Here's How Texas Gas Recovers More LPG

By using idle air compressors, the Texas Gas Corporation installs a refrigeration system which improves propane recovery with little capital expenditure.

Ruble L. Huff
Texas Gas Corporation
Winnie, Texas

TO HELP MEET the continued increasing demand for propane, the Texas Gas Corporation gets increased recovery with a refrigeration system at its gas plant in Winnie, Texas. The system uses iso-butane for a refrigerant and increases the propane recovery to 52 weight percent from a previous recovery of 32 percent. The recovery of total butanes is increased to 94 percent from 80 percent. Process design work for this installation was done by the Gasoline Plant Construction Corporation of Houston.

The choice of iso-butane for a refrigerant was made to permit the use of existing idle air compressors. Since the gas charge to the plant is not dehydrated, the temperature approach achieved by the iso-butane was adequate for this installation.

The use of an alternate refrigerant, propane, was considered but was rejected because of the low pressure rating of the idle compressors. To use high-pressure cylinders would require an additional capital expenditure of $150,000.

The Texas Gas Plant consists of two separate gas processing units. The flow diagrams for these processing units are shown in Figures 1 and 2.

The refrigeration unit was designed to cool in Plant No. 1 100 MMcf/d of inlet gas by contacting it with 650 gallons per minute of lean oil. The design for the Plant No. 2 was for 120 MMcf/d of inlet gas and 850 gpm of lean oil. By adding the refrigeration system, the degree of recovery which was expected for the Plant No. 2 is shown in Table 1.

TABLE 1
Design Recovery for Processing 120 MMCF/D Gas Charge in Plant No. 2

PRODUCT	Charge (Pounds)	Product (Pounds)	Recovery (Weight %)
C_3	158,571	82,570	52.07
i-C_4	55,910	50,375	90.10
n-C_4	71,366	70,759	99.15
i-C_5	45,557	45,329	99.50
n-C_5	31,474	31,474	100.00
C_6^+	741,146	741,146	100.00
Total	1,104,024	1,021,653	94.54

The refrigeration system permits cooling all lean oil and inlet gas to 65 F. Chilling also is supplied to the overhead of the de-ethanizers. All water coolers are retained in place, and the chillers are located downstream from these coolers. The total heat removal requirement for the chillers of both processing units is shown in Table 2.

TABLE 2
Total Chilling Requirement for Both Processing Units

SERVICE	Btu./Hr.
Lean Oil, 1500 gpm (95 F to 65 F)	10,150,000
Gas Charge, 220 Mmcf/d (95 F to 65 F)	3,400,000
De-Ethanizer	1,350,000
Total	14,900,000

Total is equivalent to 1250 tons of refrigeration. Energy required for compression will be 2250 brake horsepower.

The refrigeration system consists of three compressors rated at 800 brake horsepower each. The iso-butane refrigerant is compressed to 85 psig. After passing through a separator for the removal of lube oil, the refrigerant condenses in aftercoolers and flows to a surge drum. From there, the refrigerant is supplied to the chillers as shown in Figures 1 and 2.

The chillers are operated at a pressure of 7 pounds per square inch gage as compared with a design pressure of 12 psig. A liquid level is maintained in each chiller, and the refrigerant vapor is returned to the

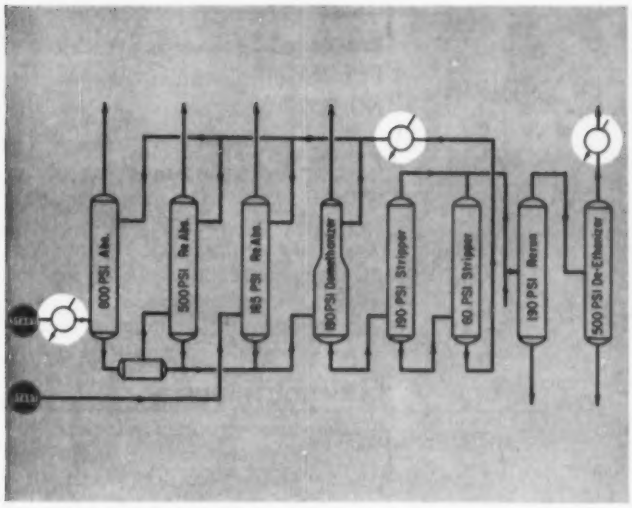


FIGURE 2—There are two separate gas processing units. Here is the flow diagram for the plant No. 2.

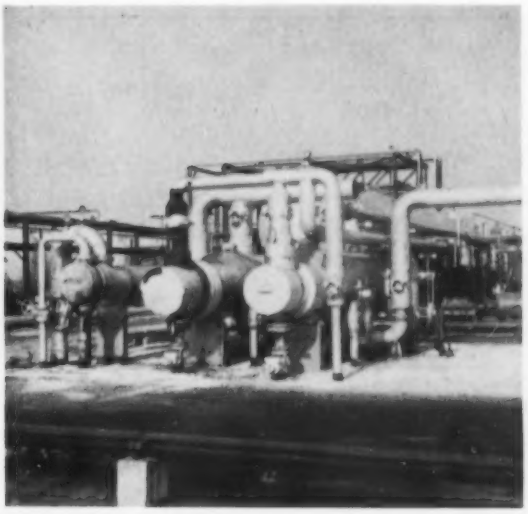


FIGURE 3—Addition of the refrigerating system increased propane recovery to 52 percent.

compressors through a suction scrubber.

A small sidestream of liquid refrigerant is passed through a steam heater to eliminate cylinder lube oil. If the lube oil were permitted to remain in the refrigerant, it would foul the chillers.

All heat exchangers, drums, and vessels for the refrigeration system were available as idle equipment. Views of some of the chillers are shown in Figures 3 and 4.

Assuming the market value for the equipment, the payout was calculated originally to be 2 to 3 years. Now that the system is in operation, a check of the plant costs and operating data indicate that this pay-out will be achieved. The operating cost for the refrigeration system is broken down in Table 3.

TABLE 3
Operating Cost for Processing 220 MMCF of Gas Per Day

ITEM	$/D
Operator	70
Iso-Butane Make-Up (15 bpd)	45
Water Treating	6
Maintenance	50
Utilities	40
Compressor Fuel (750 Mcf)	94
Total	305

Insufficient cooling of the lean oil was experienced during the initial start of the refrigeration system. To increase the heat transfer rate of the chillers, spiral promoters (one turn per foot) were placed inside the tubes. Also, the tube bundles were hydroblasted (high-pressure wet-sand blasting). Thereafter, design temperatures were achieved and maintained. ##

Meet the Author

RUBLE L. HUFF, served five years as process engineer for Texas Gas Corporation at its Winnie, Texas, plant. His background in the petroleum industry also includes service as a process engineer with Phillips Petroleum Company at Dumas, Texas, and as a laboratory technician for Jefferson Chemical Company at Port Arthur, Texas. He is a chemical engineering graduate of Louisiana State University. He recently joined Pona Engineers, Inc., as a process engineer in Houston.

FIGURE 4—All heat exchangers, drums, and vessels for the refrigeration system were available as idle equipment.

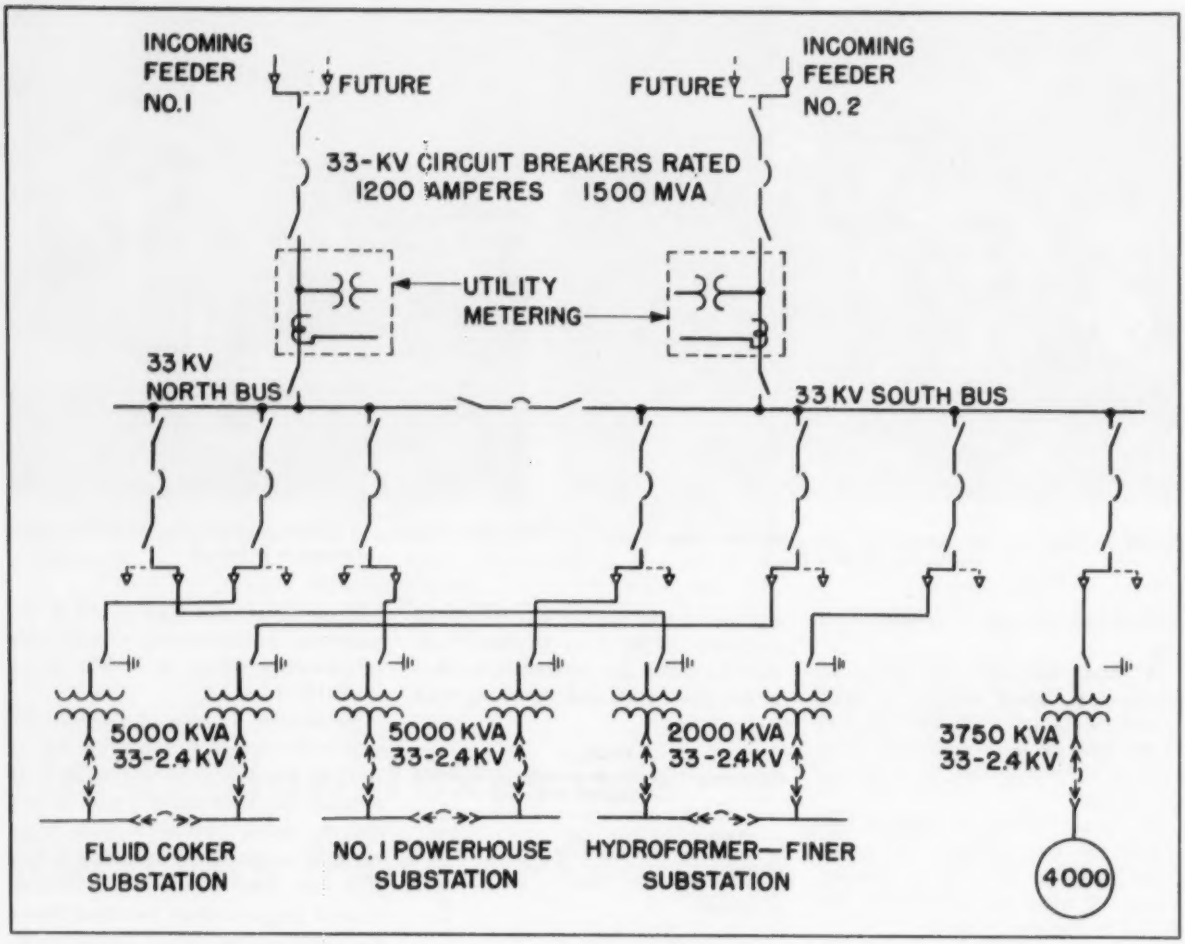


FIGURE 1—One-line diagram of the 33KV power system.

Esso Installs 34.5KV Station Switchgear

Here is how increased power demand was met when the Baltimore refinery added two process units and expanded existing installations.

W. E. Highfill
Esso Research and Engineering Company, Linden, New Jersey

MANY REFINERIES may be faced with increased power requirements in the near future. As maximum demand increases, so does the optimum distribution voltage and the required short circuit level. When these exceed the maximum ratings of 15 kv or 500 mva available in standard metal-clad switchgear, station-type cubicle switchgear offers the following advantages over the conventional open switchyard with oil circuit breakers:

- Compact construction for indoor or outdoor installations.
- Metal-enclosed for personnel

safety and equipment protection.

- Reduced maintenance.
- Increased accessibility for maintenance.
- Simplified inspection.

The petroleum industry has launched a program to improve products. As a consequence, electric power requirements increased as each new refinery process unit was designed. In 1950, process-unit induction motors seldom exceeded 500 horsepower. Today it is not uncommon to have motors of 2000 to 5000 hp. The simple radial 2400-volt power supply to a complicated modern process unit is now the exception rather than the rule. Instead, it is not unusual to have a 13.8-kv or higher supply to secondary selective substations located within process unit battery limits.

Originally, refinery steam generating plants were built to furnish low-pressure steam to process units. With the combination of high-pressure boilers and extraction or back-pressure turbine driven generators, low-pressure steam and economical electric power were obtained.

However, the present sharp rise in ratio of electric power to steam requirements has reduced the economic advantage of refinery generated versus purchased utility-generated electric power. Today, where reliable power is available, the trend is toward total purchased power with load center substations being required to receive and distribute this power.

FIGURE 2—Primary metalclad switchgear rated 34.5KV-1200 Amps-1500MVA.

Specific Problem—In 1953, the Baltimore Refinery of Esso Standard Oil Company initiated plans to add two new process units and to expand existing catalytic cracking and gas compression plants. Power was required for an estimated maximum demand of 14,000 kva.

The refinery generation system had a firm capacity of 7000 kilowatts at 2400 volts. High capital costs of new generation capacity as well as lack of physical space prohibited expansion of the existing power plant. The decision was to purchase power from the local utility company.

Distribution Voltage—Capacity was required for an ultimate load of 30,000 kva to serve the new and future loads. On this basis, 13,800 volts is the optimum distribution voltage; however, the required capacity was available from the utility only at 34.5 kv. It would have been poor design to provide transformer and switchgear capacity for only the initial 14,000 kva requirements, and it was found more economical to distribute at 34.5 kv than to provide 30,000 kva of capacity at 13.8 kv.

For reliability, two 34.5-kv feeds were obtained from the utility, either of which could carry the initial 14,000-kva load. Short circuit levels are approximately 560 mva through either feed or 1000 mva with the feeds paralleled.

34.5-kv Main Substation

Substation Building—Fortunately, a new substation could be located near the center of load. Disadvantages existed in that refinery processing equipment was less than 100 feet distant on one side and a public street was adjacent on the opposite side. Under these circumstances, an open switchyard employing bare buswork, exposed disconnect switches, and oil circuit breakers could not be permitted. A "safe" area, free at all times from hydrocarbon hazards, did not exist within an acceptable distance. It was decided to install 34.5-kv station-type cubicle switchgear in a building continuously pressurized by air drawn from a non-hazardous location. This permits use of general purpose switchgear and, in addition, provides protection of switchgear from weather, corrosive fumes, dust, and vandalism.

34.5-kv Switchgear—The station-type switchgear installed in the main substation is of the same type and construction as has been used by electric utility companies in generating stations and distribution substations for many years. However, this is the first known petroleum refinery appli-

Esso Installs 34.5KV Station Switchgear . . .

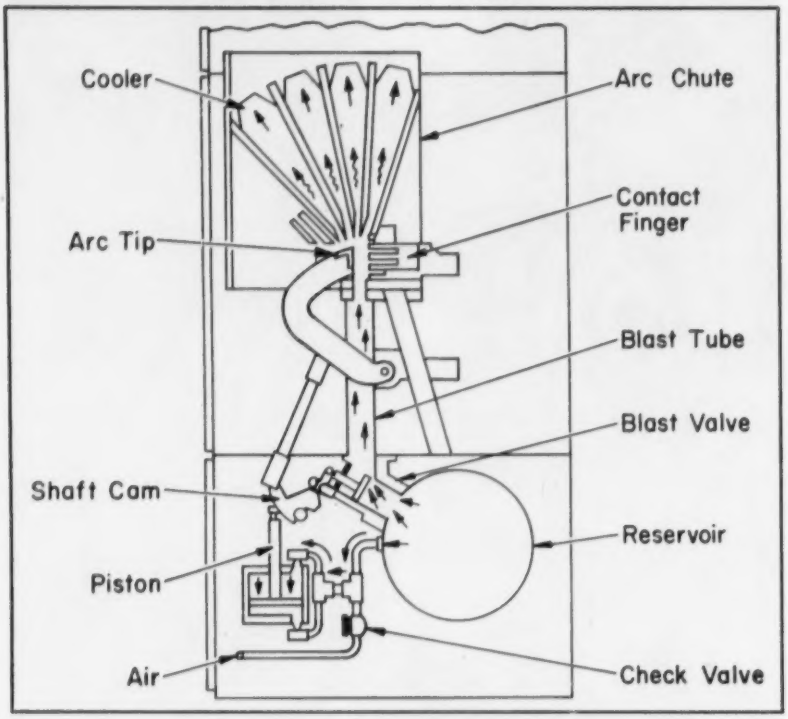


FIGURE 3—Air operated circuit breaker.

cation in the 34.5-kv class.

In station-type switchgear, each circuit breaker with its isolating disconnect switches, connections, and bus is completely enclosed in a metal cubicle, each phase circuit being segregated by metal barriers. The complete metal barrier between phases minimizes outages and eliminates the possibility of phase to phase faults. Access doors to breaker contacts, breaker mechanism, disconnect switches, and connections facilitate maintenance and inspection. Ratings from 1000 to 2500 mva are available in this construction from 15 to 34.5 kv. Switchgear of similar construction, but of the isolated phase design (vs. segregated phase) is available up to 69 kv and 5000 mva.

The arrangement of the switchgear is shown by the one-line diagram, Figure 1. The two incoming circuit breakers are normally closed, providing dual supplies to the substation. The bus tie circuit breaker normally is open but is arranged to close automatically after either incoming breaker trips on undervoltage.

The substation consists of two sections of switchgear separated by an operating aisle. The sections are connected by the segregated phase tie bus duct as shown in Figure 2. The disconnect switches are operable and accessible from this center aisle; the breakers and pneumatic mechanisms are accessible from outer aisles. Refinery and utility metering auxiliary compartments are part of the switchgear sections.

Air Circuit Breakers—The 3-pole compressed-air pneumatically-operated circuit breakers are rated 1200 amperes, 34.5 kv, 1500-mva interrupting capacity. The basic impulse level of the switchgear assembly is 200 kv. The breaker utilizes stored compressed air both to close and open the breaker and for arc interruption. High-pressure blasts of air from a reservoir are directed upward into the arc path and force arcs into the arc chute where the turbulent air flow quickly extinguishes the arc, and hot ionized gases are cooled before they pass into the atmosphere.

Figure 3 indicates the flow of compressed air through the breaker at moment of contact separation. Two separate air supply units are provided to feed compressed air into the breaker storage reservoirs. The air circuit breakers, air reservoir, and controls are shown in Figure 4.

Compressed Air System—Since the operation of the circuit breakers requires a suitable supply of compressed air, precautions are taken to guard against compressed air loss. Two sets of compressors are utilized, one set for each of the two switchgear sections, and the compressed air header of each section is brought to the tie breaker so that it has two air supplies. The system is valved so that either compressor can be shut down and the other can supply both headers.

Each circuit breaker can make two complete "close-open" operations from the air stored in its individual reservoir when the pressure is up to the normal 150 pounds per square inch. Safeguards prevent breaker malfunction if the air pressure in the individual reservoirs fall below normal: for incoming breakers, an alarm is sounded when pressure drops to 118 psi, and the breaker is tripped when pressure reaches 112 psi; for outgoing feeder breakers, the breaker is locked in its present position when pressure falls to 116 psi.

Interlocking—All live parts are enclosed by grounded metal barriers and the operating elements are interlocked for safety to operating personnel. Interlocking provided the following:

- Prevents operation of the disconnect switches when the respective circuit breaker is in the closed position.
- Prevents operation of the circuit breakers unless the disconnect switches are in the fully opened or fully closed position.
- Prevents opening the doors of the circuit breaker high-voltage compartment unless the disconnect switches are open.
- Prevents operating the disconnect switches when the doors of the circuit breaker high-voltage compartment are open.
- Prevents operating remote transformer-primary disconnect switches to "cable ground" position when the respective feeder circuit breaker is closed.

Potential and Current Transformers—The potential transformers and fuses are of the tilt-out type for easy examination. For safety, the transformer primary is automatically grounded and the secondary circuit

opened in the tilt-out position. In the operating position, the potential transformer is connected line to ground to maintain phase segregation and eliminate phase-to-phase faults. The current transformers are bushing type, mounted on the insulating bushings that extend from disconnect switch terminals to circuit breaker terminals.

Control

Dual Switchboard—Located in the same room with the station-type switchgear is a dual switchboard. The switchboard contains the local control devices, instruments, and protective relays for the air circuit breakers. Control power is obtained from a 125-volt d-c lead-acid station battery. All control devices and instruments are grouped on the hinged front panels as shown in Figure 5.

The protective relays are mounted on the stationary rear panel. For each circuit breaker there is a physically independent metal-enclosed control cubicle. These are lined up side by side and interconnected to form the complete switchboard. To provide space for multiconductor control cables, a wiring trough extends the full length underneath the dual switchboard.

The instrumentation consists of ammeters on all feeders, watthour meters on two incoming feeders, recording bus voltmeters, and indicating incoming line voltmeters. The latter is required when, after a period of supplying all load from only one of the utility supplies, it is desired to bring the second utility supply back into service; before reconnecting it is necessary to establish that normal voltage exists on the second supply.

The protective relaying consists of the following:

- Overcurrent relaying on each outgoing feeder, consisting of an instantaneous ground relay and inverse-time phase overcurrent relays. Instantaneous trip attachments on the phase relays are set to operate only on faults ahead of the 33-2.4-kv transformers, i.e., for faults on the 34.5-kv cables.
- Bus differential relaying around each of the two bus sections.
- Overcurrent relaying on each of the two incoming-line breakers, as backup for the relaying described in the foregoing. Protection consists of inverse time ground and phase overcurrent relays without instantaneous attachments, coordinating with outgoing feeder relaying.
- Reverse-power instantaneous relays on each incoming-line breaker, used only during periods of parallel operation with the bus tie and both incoming breakers closed.
- Inverse-time undervoltage relaying on each incoming-line breaker for initiating automatic transfer upon sustained loss of voltage on one utility supply. Safeguards prevent initiation of transfer on (a) loss of voltage due to a fault in the substation or in its outgoing feeders, (b) simultaneous loss of both utility supplies, and (c) simultaneous restoration of both utility supplies after a simultaneous loss (this is necessary because of the finite reset time of the inverse-time undervoltage relays).

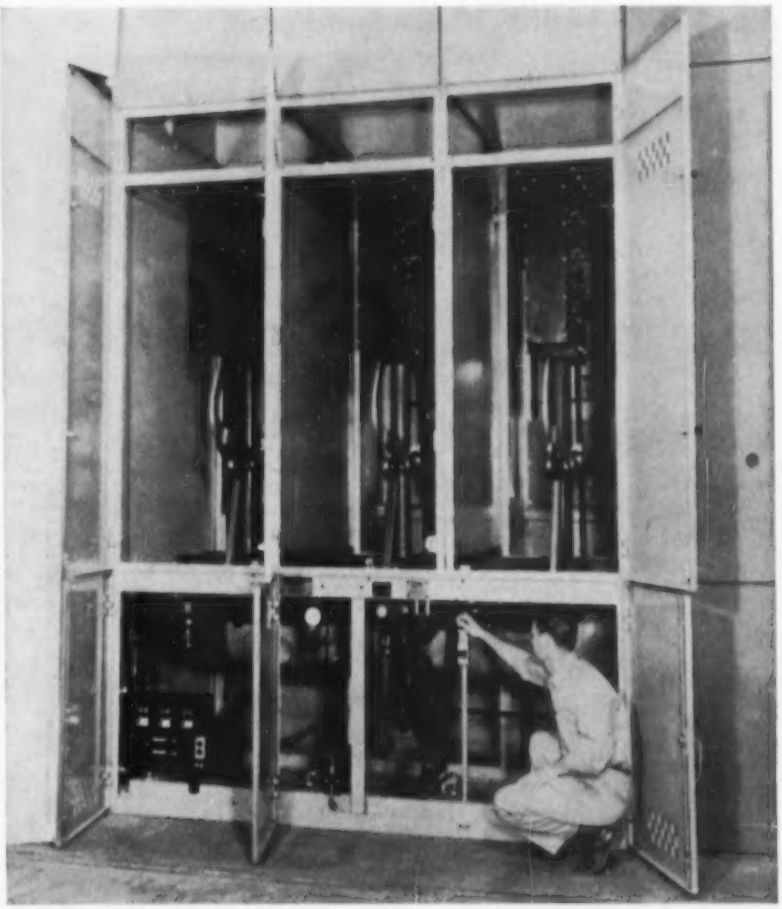


FIGURE 4—Air circuit breakers and controls in cubicles.

Supervisory Control—Since the 34.5-kv main substation is unattended it was desired to provide the following functions at the remote refinery generating plant:

- Control of all 34.5-kv circuit breakers.
- Indication of breaker position, and alarm on each breaker operation.
- Alarm on low d-c control voltage or loss of a-c charging voltage.
- Alarm on low breaker-air pressure.
- Alarm on loss of building pressure ventilation.
- Indicate incoming line voltages.
- Record incoming line currents.

It was found that a supervisory control system was more economical than separate alarm and remote-control systems, and the supervisory control was installed.

Distribution System—In the present installation, each incoming line and feeder unit is equipped with one set of potheads for bottom entrance cables but provision has been made for the future addition of a

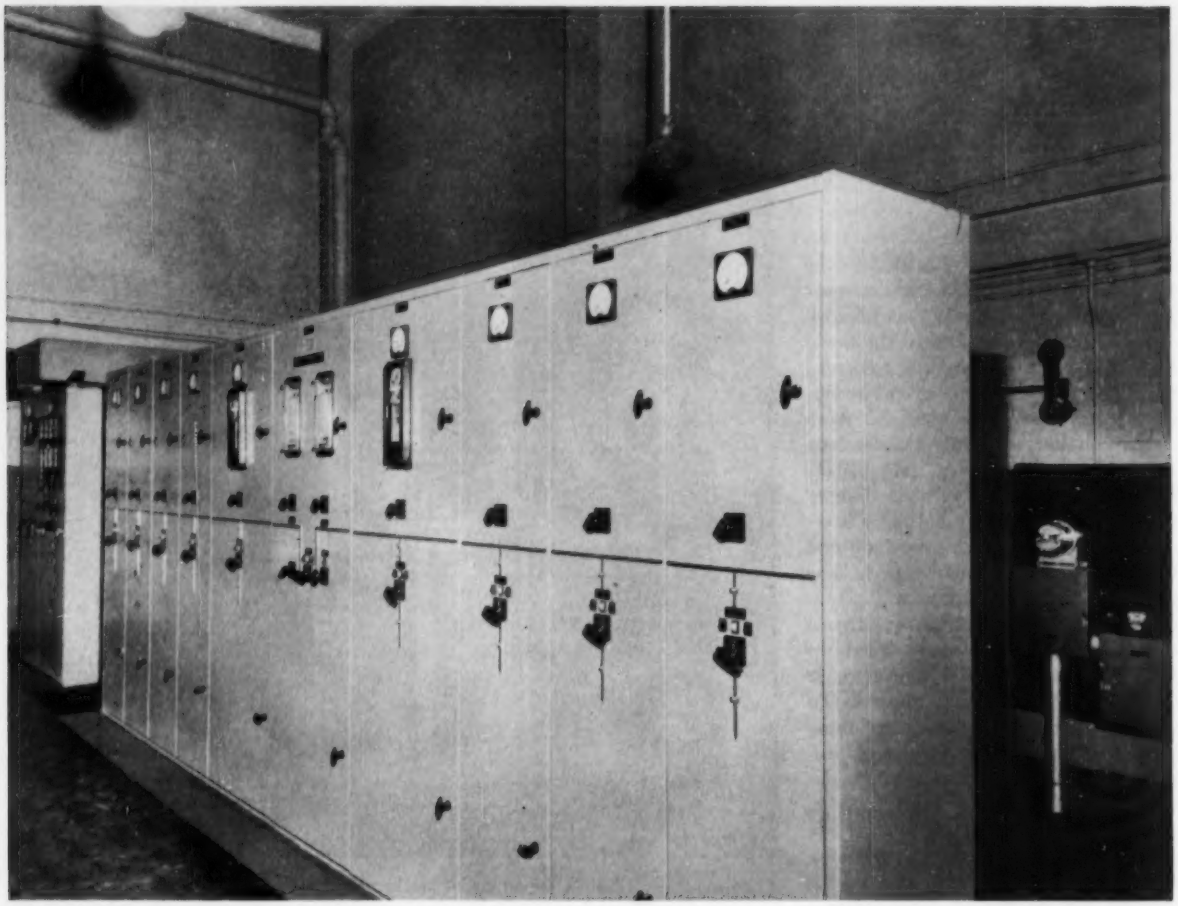


FIGURE 5—Dual switchboard containing local control devices, instruments, and protective relays for air circuit breakers.

second set of potheads to each of the incoming line and feeder units.

Feeders to unit substations consist of 35-kv, three conductor, paper-insulated, lead-covered, neoprene-sheathed cables installed in underground asbestos conduit duct banks. In one section, the cables are laid overhead in expanded metal troughs mounted 45 feet above the street on a pipe bridge. The 33-2.4-kv unit substations are located at distances up to 2000 feet from the 34.5-kv substation.

The purchased power system is independent of refinery generation.

Field Installations—The major field problem was to move into position and set the individual switchgear cubicles. Each three-phase circuit breaker and bus cubicle measures 8½ feet wide by 13½ feet deep by 17 feet high and weighs 18,000 pounds.

A unique feature of station-type switchgear is that the copper bus is not factory installed but must be inserted and clamped into the support insulators in the field.

Cable splicing and termination, and control wiring, represented a greater portion of installation time than actual switchgear installation.

The incoming line and feeder cables enter the substation from the duct-banks into a cable trench under the switchgear. Trifurcating splices were made in each 3-conductor cable changing to three single-conductor cables for termination in potheads at the disconnect switch terminals. Control cables between circuit breakers and the dual switchboard run in steel conduit imbedded in the floor.

ACKNOWLEDGMENT

The assistance of F. A. DeArcangelis of Westinghouse Electric Corporation, Newark, N. J., in preparation of this paper is acknowledged. This paper was first presented at the AIEE Petroleum Industry Technical conference, Houston, September 12-14, 1955.

Meet the Author

W. E. HIGHFILL is head of the Electrical group of Esso Research & Engineering Company's Mechanical division. With the company since 1946 and now responsible for the design, application, procurement and installation of its electrical equipment, he also has served with the Tennessee Valley Authority, in powerhouse design; with Aluminum Ore Company, as assistant plant engineer, and with the Army Signal Corps. Highfill holds a degree in electrical engineering from North Carolina State College.

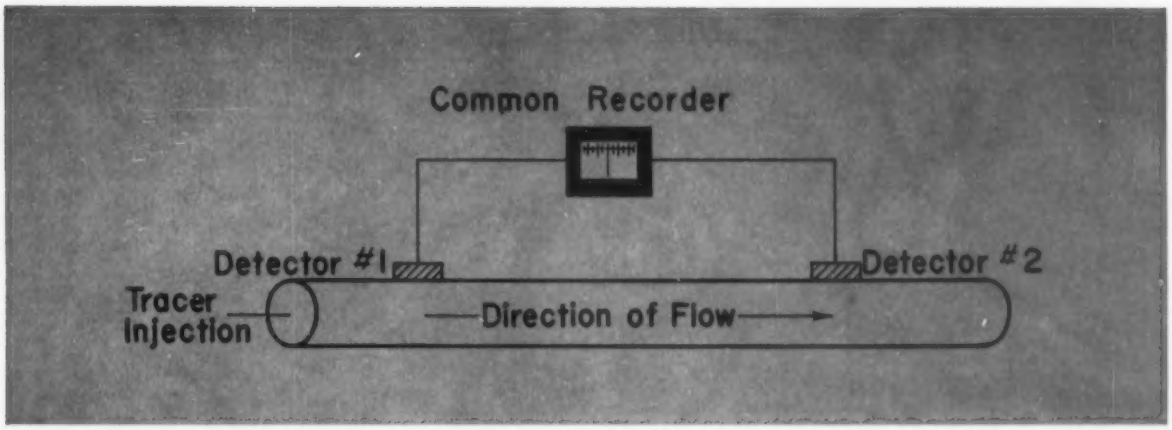


FIGURE 1—Use of tracers to determine flow rate. Two Geiger tubes with common recorder are mounted on the outside of the pipe. Tracer material is injected upstream and, passing the counters, is detected and recorded. From the time interval between the two measuring points and from the known volume of the pipe between these points, the flow rate is determined.

Take Stock of Radioactivity

Here is a timely review of the present and future uses of radioisotopes in refining processes.

E. G. Fritz
Isotope Products, Inc., Houston

THE OIL INDUSTRY can rightfully claim to have been one of the pioneers in the fruitful application of atomic energy. Years before mankind got so abruptly acquainted with the destructive forces of nuclear fission, the atom had been employed to provide information on the geological strata in oil well bore holes (radioactivity logging).

It was not, however, until the advent of atomic reactors that a wide-scale utilization of nuclear energy was possible. Radioisotopes, i.e. radioactive varieties of normally non-radioactive materials, can be produced in large quantities in the atomic reactor. The ready availability of these new materials at economical rates opened up new vistas of development. And here again the oil industry was in the forefront.

The current and foreseeable uses of radioisotopes in the refinery can be classified into four different groups:

1. Radioactive Tracer Applications
2. Radioactive Instrumentation
3. Radiography
4. Activation of Chemical Reactions by Irradiation

1. Radioactive Tracer Applications—The use of tracers has already

The atom has become a useful tool for the refiners. Here are some of the current uses:

- **Marking of interface in pipe lines**
- **Measuring flow rates in pipes.**
- **Measuring flow rate of catalyst in the cat cracker.**
- **Measuring tar entrainment in distillation.**
- **Study of flow patterns in separators and settling tanks.**
- **Engine wear studies.**
- **Determining variations in properties of lubricating oils.**
- **Detection of leaks in pipe systems and in small tanks.**
- **Finding liquid levels.**
- **Detecting density and variations in density of liquids or fluidized solids.**
- **Finding areas of corrosion.**
- **Testing soundness of welded joints and castings.**

Here are some potential uses:

- **Speeding up catalytic reactions.**
- **Increasing yields of gasoline from crude.**
- **Making new additives to improve crankcase lubricants.**
- **Promoting chemical reactions unaided by catalysts.**
- **Activation of petroleum conversion reactions by means of high energy radiation—if at all feasible and economical in the plant—might well revolutionize the whole processing procedure.**

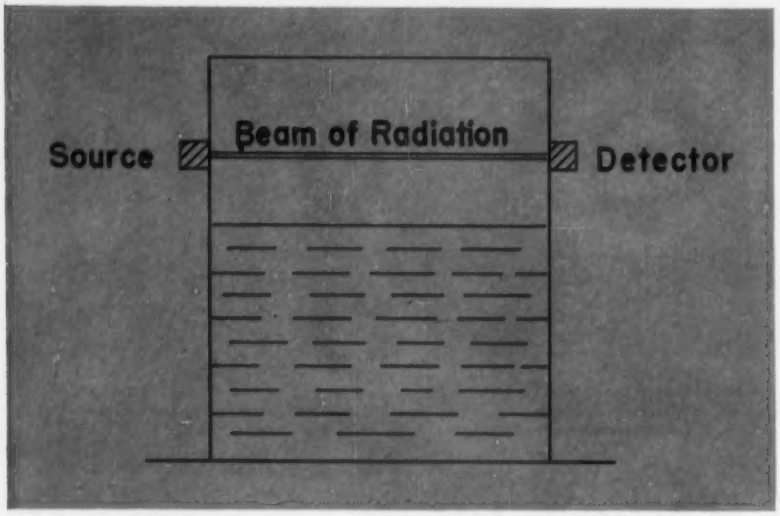


FIGURE 2—Fixed position high level alarm liquid level gage. Shown here in its simplest form, a liquid level gage consists of a gamma emitting source, mostly Cobalt-60, on one side of a tank, and of a detecting device attached to the opposite side.

been recognized by the refiner as a valuable adjunct in a variety of processes.

In multiple-products pipe lines, the interface can be marked by injecting an oil-soluble radioisotope compound. The latter can, by means of a Geiger counter, be fairly accurately detected and the succeeding product can thus be readily diverted to its proper storage vessel.

This pinpoint detection eliminates the old cumbersome method of drawing successive samples and testing their physical properties. Furthermore, this method gives a better indication of the extent of mixture of the two products at the interface. Therefore, reprocessing of mixed product is reduced. One refiner claims that the cost of the tracer and measuring equipment was recovered within one week of operation.

Flow rates of fluids in pipes can be determined in a similar manner as interfaces. Two Geiger tubes with a common recorder are mounted on the outside of the pipe, a certain distance apart (Figure 1). The tracer material is injected upstream and, passing the counters, is detected and recorded. From the time interval between the two measuring points and from the known volume of the pipe between these points, the flow rate is determined.

The measurement of the flow rate of the catalyst in a catcracker is based on the same principle. There are also two points of measurement, an upper and a lower point. A few tracer beads each about one-eighth inch in diameter are admixed to the catalyst and the time necessary for a bead to migrate from point one to point two is measured.

In several refineries in this country, catalyst flow rate meters of this type are in operation. These installations have proven their economic value not only in maintaining proper flow rate conditions but also in a reduction of catalyst attrition.

Tracers are also successfully applied in the measurement of tar entrainment in distillation and in determining the extent of mixing in various processes. The method can also be used to study flow patterns in separators and settling tanks.

Engine wear studies are another most interesting angle of tracer application. The piston rings of a standard engine are irradiated in a nuclear reactor. Some of the iron atoms in the rings become radioactive. The engine in which these piston rings are used is then run with the lubricating oil to be tested. In the course of the test run, some of the radioactive atoms will wear off the rings.

The amount of loose radioactivity is, therefore, a measurement of the wear. Variations in the properties of lubrication oils can thus be determined. One oil refiner estimates that this method for investigation has accomplished in four years at a cost of $35,000 what normally would have required 60 years and a budget of $1 million.

Finally, radiotracers are used in the detection of leaks in pipe systems and in small tanks, especially where the surface is not readily accessible to visual inspection due to some sort of covering, be it a wrapping or a layer of concrete. In this type of leak detection, the tracer is introduced into the system in very diluted form.

Often pressure is applied to squeeze the solution out of close-lipped fractures or pinholes. These leaks are located by a Geiger counter or scintillometer. In most cases, this pinpoint location saves a lot of time, labor, and material because the operation can be done quickly and the area where covering has to be removed is minimized to the place where repair is necessary.

2. Radioactive Instrumentation—In this category fall a number of instruments which have two features in common:

- A radioisotope is an integral part of the instrument.
- The radioisotope does not make physical contact with the material to be measured.

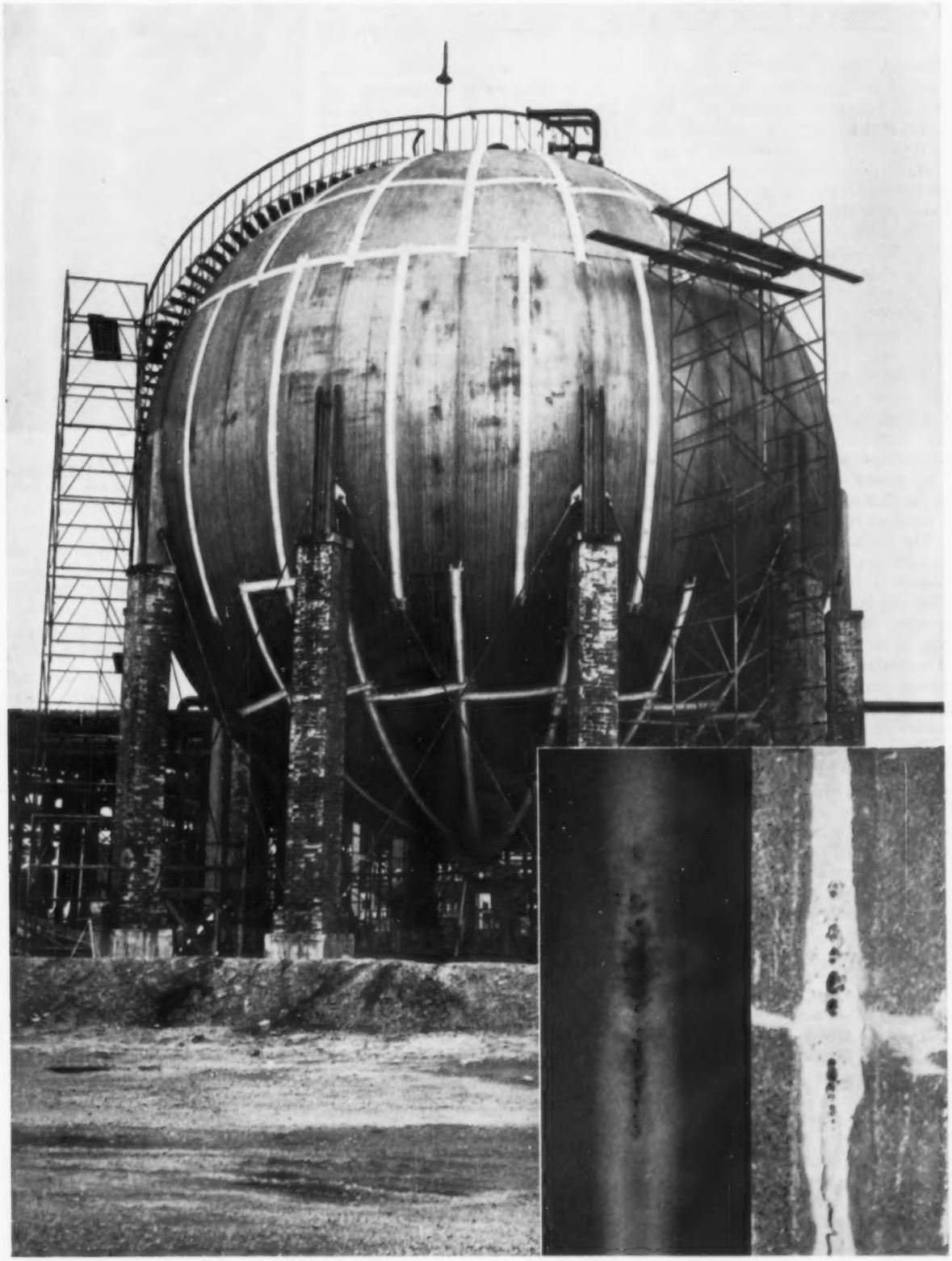
Here are some members of this group which are of interest to the refiner:

Liquid Level Gages. In its simplest form, a liquid level gage consists of a gamma emitting source, mostly Cobalt-60, on one side of a tank, and of a detecting device attached to the opposite side (Figure 2). While the liquid is below the beam of radiation, the detector indicates that the radiation has an unobstructed path. As soon as the level rises above this preset height the beam is cut off by the liquid.

Other types of level gages on the market are capable of indicating any level in the tank. These gages are very suitable for automatic control from a convenient central point in the refinery.

Density Gages. Density gages are instruments designed primarily to detect density and variations in density of liquids or fluidized solids. This is done by measuring the attenuation of gamma radiation in the mass of the substance under consideration.

The essential features of a typical density gage are these: A shielded source is attached to one side of a



FIGURES 3 and 4—A sphere with film cassettes attached to welded joints is shown here. This method (radiography) of testing soundness of welded joints and castings is a much used tool of inspection. Defects in weld on storage tank (inset) are revealed here by radiography using iridium-192 (left). And same section photographed (right) after removal of weld crown.

pipe. A small collimated beam of gamma rays penetrates the pipe and the substance to be measured. The attenuated beam on the opposite side is detected by a pressurized ionization chamber. The distance between source and detector is fixed by the diameter of the pipe.

The mass of the substance in the pipe determines what percentage of the gamma rays are absorbed on their way to the detector. This portion of the gamma rays generates a signal in the detector which is fed to an amplifier.

Before entering the amplifier however, this signal is balanced against a second signal from another source and detector combination, permanently associated with the amplifier. The second signal after adjustment to the desired balancing value, is then a constant reference.

The different signal which is fed into the amplifier is a measure of the density of the material in the pipe. This nul balance arrangement is inherently very stable. It allows the gage to be used for the measurement of material having a wide range of density and volume. And here again, the signal can be used for automatic control of density if required.

The sensitivity is such that the instrument can be applied for the measurement of petrol fractions and for controlling any batch process in which there is a change in density associated with the end product. Due to its non-contacting operation, the instrument can, in most cases, be directly attached to existing installations without any changes. The gage does not present any fire or radiation hazard.

Corrosion Gage. The corrosion gamma-gage is based on a similar principle as the density gage. However, instead of the density of a fluid, the thickness of a pipe wall or a tank wall is measured.

The measuring head consists of both the shielded source and the detector. A fine beam of radiation is sent into the material. A portion of this radiation is reflected by the material and picked up by the detector. This reflected portion of the beam is correlated with the thickness and composition of the material.

In this manner, areas of corrosion on tank bottoms, in pressure piping, and in tank walls can be determined.

3. Radiography—Radiography as a method of testing the soundness of welded joints and castings is an old recognized tool of inspection. But here again, artificial radioactivity has considerably widened the scope of its application and made the procedure a great deal more efficient and economical.

Large spherical storage tanks are now radiographed in one exposure by means of a strong radioactive source positioned in the center of the vessel. Figure 3 shows such a sphere with the film cassetes attached to the welded joints. Cylindrical storage tanks are examined in a similar manner.

The inspection of high-pressure piping and field welds on catcrackers was made feasible by radioisotopes. On new construction radiography assures up-to-the-standard welding, and, where spot radiography only is applied, it is a vigilant watchdog over the welders to insure good workmanship.

Meet the Author

E. G. FRITZ, born in Germany, studied natural sciences and philosophy at Germany's Johannes-Kepler College and Stuttgart Technische Hochschule. In 1951, he migrated to Canada where he joined Isotope Products, Ltd., at Oakville, Ont. This firm is engaged in applying atomic energy to industry, manufacturing radioactive thickness gages, density gages and radiography equipment. It also maintains a radiographic inspection service. Fritz came to the U. S. in 1955, as general manager of the Radiography division of Isotope Products, Inc.

But on old storage and pressure vessels too, radiography can spare the refiner a lot of downtime, troubles, and expense. After several years of service, welds on storage vessels often show cracks and preferential attack by corrosion on weld defects (Figure 4). Serious ruptures can be avoided if timely re-inspection is applied.

One major company subjects their storage vessels to complete radiographic inspection every five years of service.

4. Activation of Chemical Reactions by Irradiation—When gamma radiation impinges on material, the energy of the radiation can break up the molecular structure of certain materials. Free radicals may thereby be formed which in turn may engage in cross-linking and produce new molecules.

In November, 1955, Esso Research and Engineering Company disclosed what radiation can do in petroleum conversion reactions. Esso researchers found that gamma radiation can speed up catalytic reactions, increase yields of gasoline from crude, make new additives to improve crankcase lubricants, and promote chemical reactions unaided by catalysts.

Of course these findings are still in the experimental stage and, at this time, it is difficult to predict whether, and, if so, when such an application will become commercially feasible in the refinery.

Some of the applications described above are already routinely employed in refineries. Amongst these proven commercial uses are the liquid level gages, flow rate meters, interface marking, radiography, and density gages. Thus the atom has already conquered a firm place in the refinery, serving primarily in the functions of testing, measurement and control. With the steady progress of automation, the extent of these applications will commensurately increase.

No doubt there are still a great many other potential uses of radioactive instrumentation and of the tracer principle in the refinery but a good deal of application engineering needs be done yet to reveal the specific loci of application.

Activation of petroleum conversion reactions by means of high energy radiation if at all feasible and economical in the plant might well revolutionize the whole processing procedure. ##

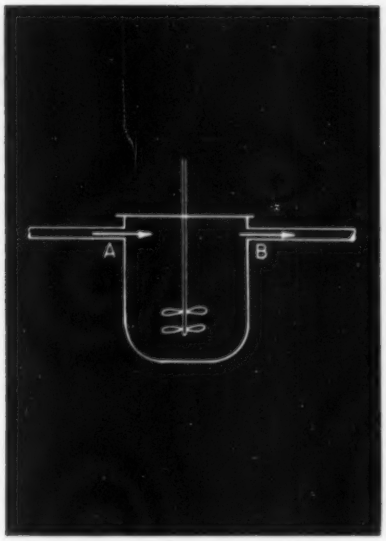


FIGURE 5—If the composition of the inlet (A) suddenly changes, the composition of the outlet (B) may be determined.

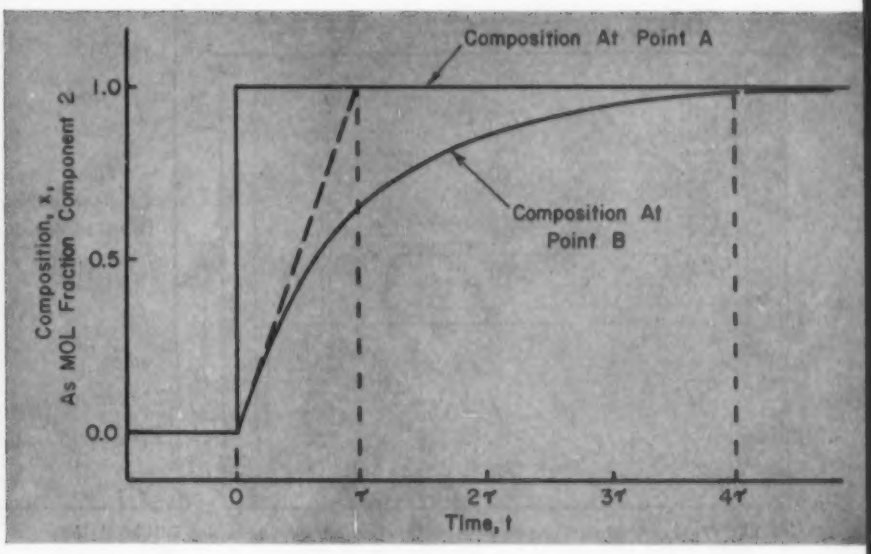


FIGURE 6—After the time (τ) the outlet has undergone a change equal to 0.62 of the total inlet change.

Part 2

Automation Today

This article is the second of a series which is designed to acquaint the reader with some of the basic concepts of automatic control and their application to the operations of the petroleum and chemical industries.

Here are a few examples on how to get away from the trial-and-error methods for operations of various complexity.

Theodore J. Williams
USAF Institute of Technology
Wright-Patterson AFB, Ohio

IN THE FIRST article of this series, the control loop concept of automatic control was outlined and mention was made of the part which each of the elements of the loop has in the ultimate control of the process. Also mentioned was the fact that the operating characteristics of each of these elements under transient or changing conditions must be known to the control engineer if he is to use the modern servomechanism design procedures in setting up his control scheme rather than an empirical or a "cut and try" method.[4,12]

BASIC PROCESS CHARACTERISTICS

It must be made clear at this point that due to the complexity of the average refinery operation the use of the servomechanism techniques as outlined herein is possible only with considerable difficulty unless one has the aid of an electronic computer. However, an outline of the use of these methods is so valuable for a true appreciation of the concepts of automatic control that this approach will be used. Let us now consider some of the possible types of characteristics. We will consider each of them in their simplest form first and then show how they may be combined in a more complex case.

The first-order transfer function is exemplified by an ordinary binary mixing process. Consider the simple apparatus of Figure 5 and assume that the kettle gives complete mixing at all times. Now let us further assume that pure component 1 has been flowing into the kettle. Suddenly the feed composition is changed so that now pure component 2 is being introduced at the same rate as previously used for component 1. The resulting com-

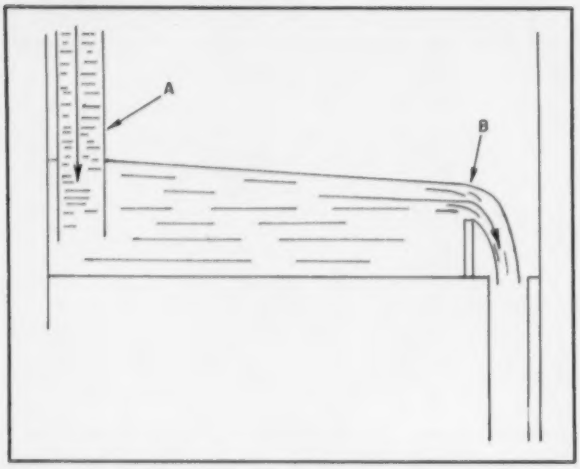


FIGURE 7—The flow over the weir of a fractionating column may be made to vary according to the first-order transfer function.

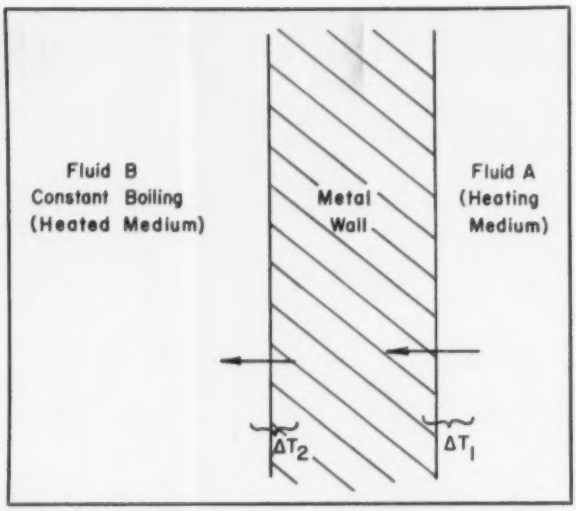


FIGURE 8—A sudden increase in the temperature of the fluid (A) will not immediately result in a greater rate of boiling in fluid (B).

position of the entering stream at point A has been plotted in the graph of Figure 6 as the mol fraction of component 2 and thus shows a sharp jump to pure component 2 at zero time or at the beginning of the experiment. This sudden change in the value of the composition of the entering stream at point A is known as a *step-function*.

We can now write a differential equation expressing the composition appearing at point B as follows:

$$\frac{dx_B}{dt} = (x_A - x_B)\frac{F}{C} \qquad (1)$$

where x_A and x_B are the compositions at points A and B respectively. F is the flow rate into the kettle and C is the capacity of the kettle, both in consistent units. Equation (1) may be rearranged as follows:

$$\frac{dx_B}{dt} + \frac{x_B F}{C} = \frac{x_A F}{C}. \qquad (2)$$

The methods of *operational calculus*[6,9] allow us to introduce a new symbol at this point called an *operator*. By this notation we define the symbol, p, the operator, as

$$p = \frac{d}{dt}. \qquad (3)$$

If this symbol is introduced into Equation (2) above and one allows the operator, p, to have algebraic properties, the following notation is possible. (These algebraic properties are permissibie only so long as the differential equations involved are linear.)

$$px_B + \frac{x_B F}{C} = \frac{x_A F}{C}$$

$$x_B\left(p + \frac{F}{C}\right) = x_A\frac{F}{C}$$

$$x_B = \frac{x_A\dfrac{F}{C}}{p + \dfrac{F}{C}}$$

$$x_B = \frac{x_A}{p\dfrac{C}{F} + 1}$$

$$\frac{x_B}{x_A} = \frac{1}{p\dfrac{C}{F} + 1} = \frac{1}{\tau p + 1} \qquad (4)$$

The expression $\frac{1}{\tau p + 1}$ is called a *first-order transfer function* and the symbol $\tau = \frac{C}{F}$ is called the *time constant* of the process of mixing in the vessel. It can be seen that the quantity, τ, has units of time equivalent to the units of time used in expressing the flow rate into and out of the kettle. The expression $\frac{1}{\tau p + 1}$ is also called the equation of a *single-capacity system* since there is only one

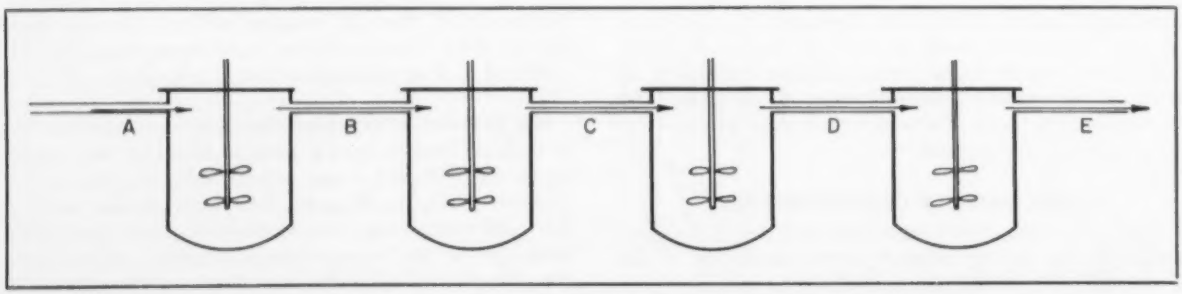


FIGURE 9—A higher-order transfer function is required to represent several kettles connected in series.

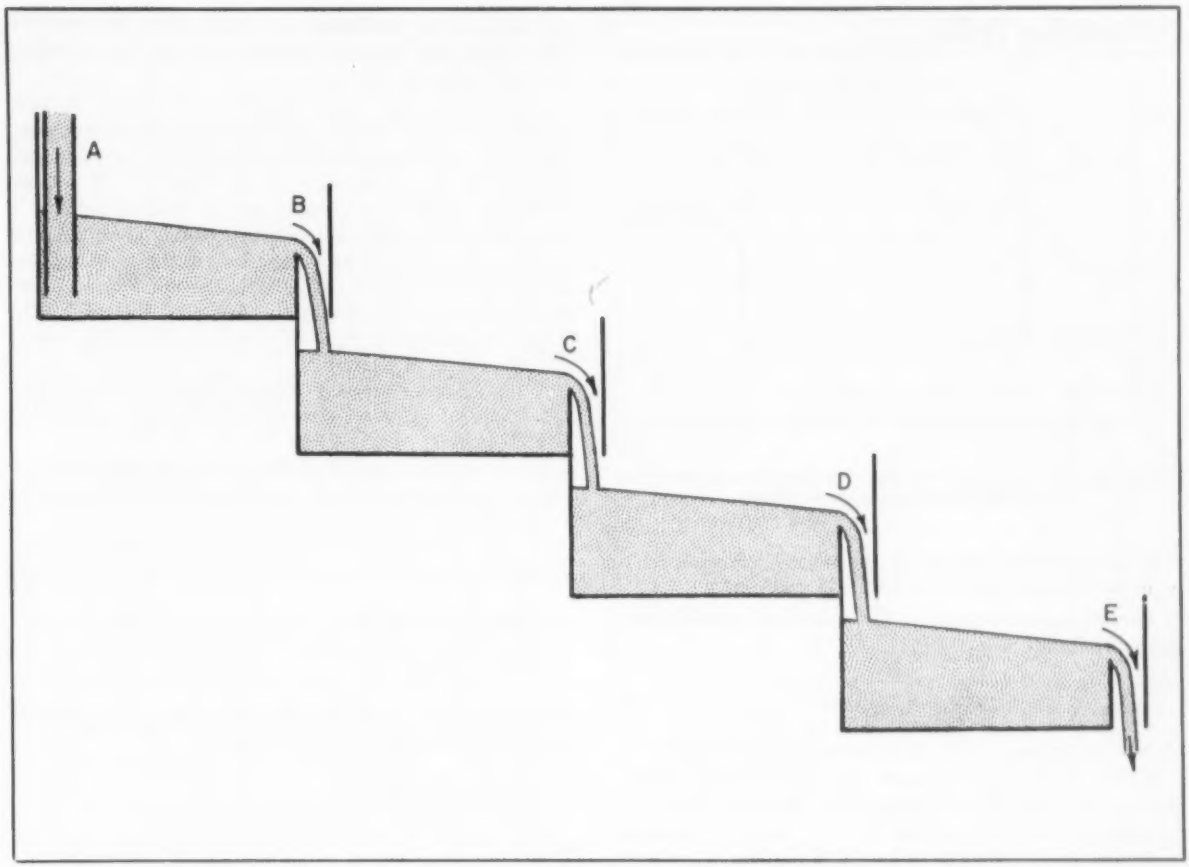


FIGURE 10—Many higher-order transfer functions may be considered as combinations of several first-order systems.

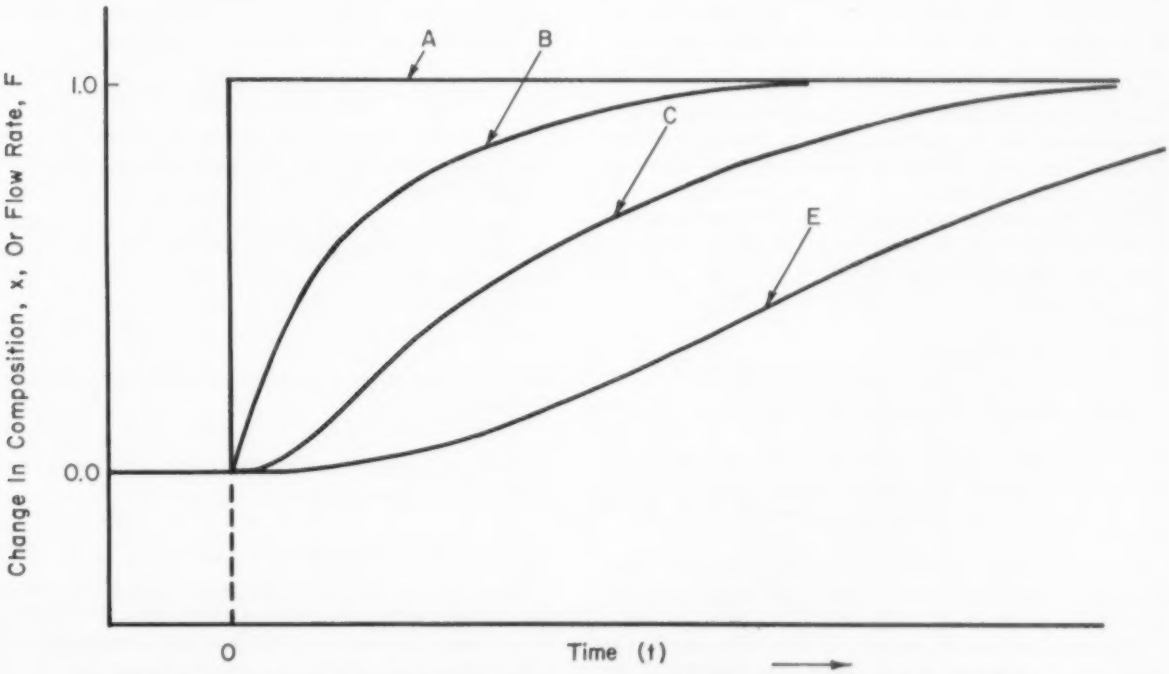


FIGURE 11—This is the way the compositions would change for the multiple-capacity systems shown in figures 9 and 10.

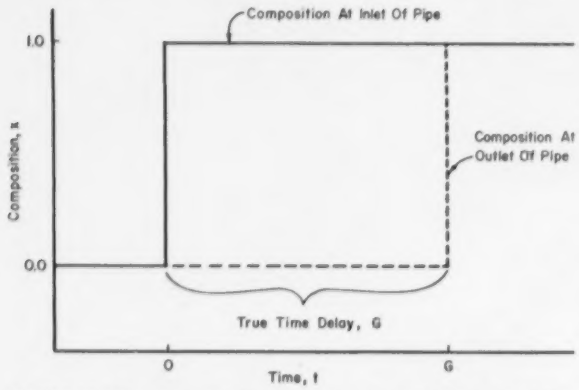


FIGURE 12—The representation of plug flow through a section of pipe by a mathematical expression is difficult.

place available for storage of the material flowing in at point *A*, the capacity, *C*, of the kettle itself.

The solution of Equation (1) by classical means[11] gives the expression:

$$x_B = \left(1 - e^{-\frac{t}{\tau}}\right) x_A. \tag{5}$$

Here, e is the base of the Naperian or natural logarithms.

If this expression is plotted, the curve labeled "composition at point *B*" on Figure 6 is obtained. Some interesting points concerning the quantity τ can be obtained from this graph. Consideration of Equation (1) shows that the initial rate of change of x_B is equal to $\frac{F}{C}$. Therefore if the initial slope of the x_B vs. t curve is extended until it intersects the x_A curve the amount of time subtended on the abscissa is equal to τ, the time constant. In Equation (5) this time when $t = \tau$ means that:

$$x_B = (1 - e^{-1})\, x_A = 0.623 x_A. \tag{6}$$

Therefore the value of τ can be found whenever the *output variable*, here x_B has undergone a fraction equal to 0.623 of the total change originally imposed upon the *input variable*, x_A. Finally it can be shown that x_B will reach $0.98x_A$ after a time equal to 4τ. The reader should verify for himself at this point that the above considerations also hold even if the change in x_A is less than the complete range from 0 to 1.0 as used here. In other words:

$\Delta x_B = 0.623\ \Delta x_A$ in one τ,
$= 0.980\ \Delta x_A$ in four τ regardless of the size of Δx_A.

Many dynamic processes in engineering may be considered as single-capacity systems and are thus expressible as first-order transfer functions. For example, weirs can be readily designed so that the rate of output flow is directly proportional to the height of the liquid over the weir.

If the plate in Figure 7 is fitted with such a weir and if the input flow at point *A* is suddenly changed, the output flow at point *B* will vary only as the level of liquid on the tray is raised or lowered by the difference in the flow rates at points *A* and *B*. Thus the capacity of the tray will influence the rate of change of flow at *B* and a graph similar to Figure 6 would again be obtained. This particular type of transfer function is sometimes called a *hydraulic lag*.

Consider also the situation pictured in Figure 8. Here a boiling liquid *B* is being vaporized by heat transferred through a metal wall from the heating fluid *A*. A sudden increase in the temperature of the fluid *A* will not immediately result in a greater rate of boiling in fluid *B* since the metal wall must first be heated. Thus the heat capacity of the vessel walls functions in the same manner as the liquid capacity of the weir tray of Figure 7 and the composition storage in the kettle of Figure 5. The reader can probably think of many more applications of this same type of analysis.

A higher-order transfer function is required for *multiple-capacity system* of several kettles connected together as in Figure 9.

By an analogy similar to Equation (4), the composition x_C can be represented as a function of composition x_B as follows:

$$x_C = \frac{x_B}{\tau_B p + 1} \tag{7}$$

but from Equation (4),

$$x_B = \frac{x_A}{\tau_A p + 1}.$$

Therefore since we have allowed ourselves to perform algebraic operations on the operator p,

$$x_C = \frac{\left(\frac{1}{\tau_A p + 1}\right) x_A}{\tau_B p + 1} = \frac{x_A}{(\tau_A p + 1)(\tau_B p + 1)}$$

Then

$$\frac{x_C}{x_A} = \frac{1}{(\tau_A p + 1)(\tau_B p + 1)} \tag{8}$$

Equation (8) is a second-order transfer function since this same system is represented classically by the following differential equation which is second order.

$$\frac{d^2 x_C}{dt^2} + 2\frac{F}{C}\frac{dx_C}{dt} = \left(\frac{F}{C}\right)^2 (x_A - x_C). \tag{9}$$

By a similar development it can be shown that the output composition at point E, x_E, is related to the input composition, x_A, by the relation:

$$\frac{x_E}{x_A} = \frac{1}{(\tau_A p + 1)(\tau_B p + 1)(\tau_C p + 1)(\tau_D p + 1)}$$

If all τ's are equal,

$$\frac{x_E}{x_A} = \frac{1}{(\tau p + 1)^4} \tag{10}$$

This, of course, gives a fourth order differential equation by classical means.

The flow system of Figure 10, when treated by similar methods, will give the flow rate ratio $\frac{F_E}{F_A}$, again as a fourth-order transfer function:

$$\frac{F_E}{F_A} = \frac{1}{(\tau'_A p + 1)(\tau'_B p + 1)(\tau'_C p + 1)(\tau'_D p + 1)} \tag{11}$$

Thus many second and higher-order transfer functions can be considered as combinations of several first-order systems. Graphs of either of these examples when plotted as in Figure 6 will appear as shown in Figure 11.

It is possible also to have second or higher order trans-

fer functions which are not factorable completely into simple first-order expressions. Thus it is possible to have expressions such as

$$\frac{x_N}{x_A} = \frac{1}{p^n (\tau_1 p + 1)(\tau_2 p + 1) \ldots\ldots}, \qquad (12)$$

or

$$\frac{x_N}{x_A} = \frac{1}{p (\tau_1 p + 1)(\tau_2^2 p^2 + \delta p + 1) \ldots}, \qquad (13)$$

where

$$\delta \neq 2\tau$$

Many hydraulic and pneumatic devices are of the type which may be represented by Equation (13).[4] These equations can be derived, as was the first-order transfer function, by writing the differential equation of the process; substituting the operator, p, for each $\frac{d}{dt}$ in the equation; solving for the ratio of the output variable to the input variable; and then factoring the resulting expression. Since such expressions are very hard to evaluate by ordinary mathematical means, the expression is often assumed to fall under the category of Equation (10) or Equation (12).

The types of expressions first considered are also known as *exponential time delays* with the first-order transfer function also being called a *simple time delay.*

True-time delay is another type of time delay that is of major importance in considering the dynamics of petroleum and chemical processes. This is the concept of the time required to traverse a long pipe or a piece of apparatus wherein it is assumed that no mixing occurs. An example of this is "plug flow" through a long pipe or a condenser. Figure 12 gives a graphical representation of such an event. The reader probably will consider this as ridiculously simple concept and one readily derived from common sense considerations. This is perfectly true. However, the representation of such an occurrence by a mathematical expression is difficult. It is only possible by the methods of the operational calculus or the *Laplace transformation*[6,9] and then as follows:

$$x_A = e^{-pG} x_B \qquad (14)$$

The mathematical derivation of this expression is beyond the scope of this presentation. The reader who is interested is referred to a discussion of the real-translation theorem in any of the standard texts[6,9] on operational calculus or the Laplace transformation. Despite the very great importance of such an expression in describing the process dynamics of the various components of a refinery, with their long pipe lines and large holdups, its inclusion in an equation make the solution of the resulting equation almost impossible by conventional, that is, classical means, except for the very simplest cases. These equations are, however, readily solvable by modern computing machines such as the electronic differential analyzer so a remedy to our dilemma is at hand.

The actual process found in the refinery is of course neither purely an exponential time delay nor completely a true time delay. Figure 13 shows one possible occurrence and shows how it may be approximated by a combination of one true time delay and one exponential time delay. The resulting dynamic equation for the composi-

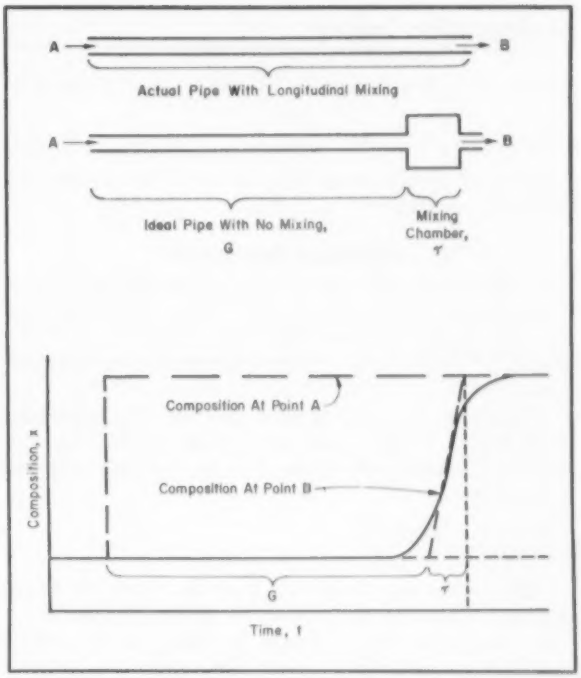


FIGURE 13—A section of actual pipe may be represented by a true time delay and an exponential time delay.

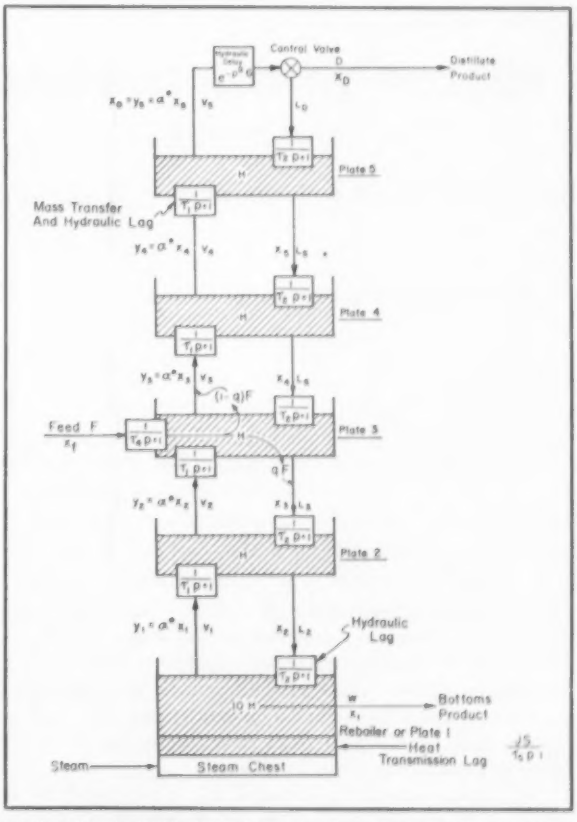


FIGURE 14—A distillation column may be represented by a series of equations involving material balances and heat balances around various sections.

tion at point *B* as a function of that at point *A* would be

$$x_B = \frac{e^{-pG} x_A}{\tau p + 1} \tag{15}$$

expressions of this nature may be solved on an electronic analogue computer.

COMPLEX PROCESSES

Continuous distillation is one of a number of complex processes which may be represented by combining some of the simple relations discussed previously. Consider Figure 14 which gives a block diagram of a small distillation column.

From our discussion of flow over weirs in connection with Figure 7, the reader can readily see that we may express the liquid rate between plates to a close approximation by

$$L_n = \frac{L_n + 1}{\tau_2 p + 1}. \tag{16}$$

Also, when one considers that the vapor is forced through a plate by the pressure in the vapor space below the plate, and that a change in this pressure involves capacity considerations again, the vapor rate between plates approximates very closely to

$$V_n = \frac{V_n - 1}{\tau_1 p + 1}. \tag{17}$$

Therefore the vapor rates in the column are expressed by the relations:

$$\left.\begin{aligned} V_2 &= \frac{V_1}{\tau_1 p + 1} \\ V_3 &= \frac{V_2}{\tau_1 p + 1} + (1 - q)\frac{F}{\tau_2 p + 1} \\ V_4 &= \frac{V_3}{\tau_1 p + 1} \\ V_5 &= \frac{V_4}{\tau_1 p + 1} \end{aligned}\right\} \tag{18}$$

The column liquid rates are as follows:

$$\left.\begin{aligned} L_5 &= \frac{L_D}{\tau_2 p + 1} \\ L_4 &= \frac{L_5}{\tau_2 p + 1} \\ L_3 &= \frac{L_4}{\tau_2 p + 1} + q\frac{F}{\tau_2 p + 1} \\ L_2 &= \frac{L_3}{\tau_2 p + 1} \\ W &= \frac{L_2}{\tau_2 p + 1} - V_1. \end{aligned}\right\} \tag{19}$$

The expressions containing qF and $(1 - q)$ F determine the effect of feed rate and feed quality changes upon the column and would always be included in the equation for the feed plate (plate 3). Different time constants are used here since the physical characteristics of the feed system may be different from those of the system transferring liquid from plate to plate.

The boilup rate of the reboiler, V_1, is a function of the rate of steam condensation in the steam chest and the heat capacity of the reboiler and insulation. The latter is important in considering the transfer function involved in evaluating the capacity or exponential lag of this system when a larger temperature is necessary to increase the boilup rate. V_1 may therefore be expressed as

$$V_1 = \frac{JS}{\tau_6 p + 1} \tag{20}$$

where S is the steam condensation rate and J is a constant relating steam condensation rate in the steam chest to vapor boil-up rate in the reboiler.

If we assume plug flow through the condenser, L_C, the flow rate leaving the condenser, will be a function of V_5 as follows from Equation (14),

$$L_C = e^{-pG_6} V_5. \tag{21}$$

Since L_D, the reflux rate, equals the condenser rate minus the distillate rate, D, L_D is a function of V_5.

$$L_D = (e^{-pG_6} V_5) - D. \tag{22}$$

We now have a complete description of the fluid flow in the column under all conditions. When these equations are combined with the corresponding equations for the column compositions derived by a differential material balance, the following expressions result:

$$\left.\begin{aligned} \frac{dx_5}{dt} &= \frac{V_4}{H_5} y_4 + \frac{L_D}{H_5} y_5^* - \frac{V_5}{H_5} y_5 - \frac{L_5}{H_5} x_5 \\ \frac{dx_4}{dt} &= \frac{V_3}{H_4} y_3 \quad \frac{L_5}{H_4} x_5 - \frac{V_4}{H_4} y_4 - \frac{L_4}{H_4} x_4 \\ \frac{dx_3}{dt} &= \frac{V_2}{H_3} y_2 + \frac{L_4}{H_3} x_4 - \frac{V_3}{H_3} y_3 - \frac{L_3}{H_3} x_3 + \frac{F}{H_3} x_f \\ \frac{dx_2}{dt} &= \frac{V_1}{H_2} y_1 + \frac{L_3}{H_2} x_3 - \frac{V_2}{H_2} y_2 - \frac{L_2}{H_2} x_2 \\ \frac{dx_1}{dt} &= \frac{L_2}{H_1} x_2 - \frac{V_1}{H_1} y_1 - \frac{W}{H_1} x_1, \end{aligned}\right\} \tag{23}$$

where $y = \dfrac{\alpha x}{1 + (\alpha - 1)x} = \alpha x^*$

Thus, the characteristics of the column are completely specified.

Since $L_D y_5^*$ represents material which has passed through the condenser,

$$y_5^* = e^{-pG_6} y_5. \tag{24}$$

The resulting flow rate equations could be combined in the manner of Equation (10), but since each of the individual rates appears in the composition equations, they are probably best kept in the form of Equations (18) and (19).

In the event it is desired to consider mixing in the condenser, Equations (22) and (24) can be changed to conform to Equation (15).

$$L_D = \frac{e^{-pG_6} V_5}{\tau_3 p + 1} - D. \tag{22a}$$

$$y_5^* = \frac{e^{-pG_6} y_5}{\tau_3 p + 1} \tag{24a}$$

The composite set of equations needed to completely express the dynamic characteristics of the 5-plate column thus consists of 17 simultaneous differential equations. This system of equations is far too complex for evaluation by hand computation methods but has been readily solved by electronic computers.[16] This will be discussed in future articles.

End of Part 2

Part III will appear in an early issue.

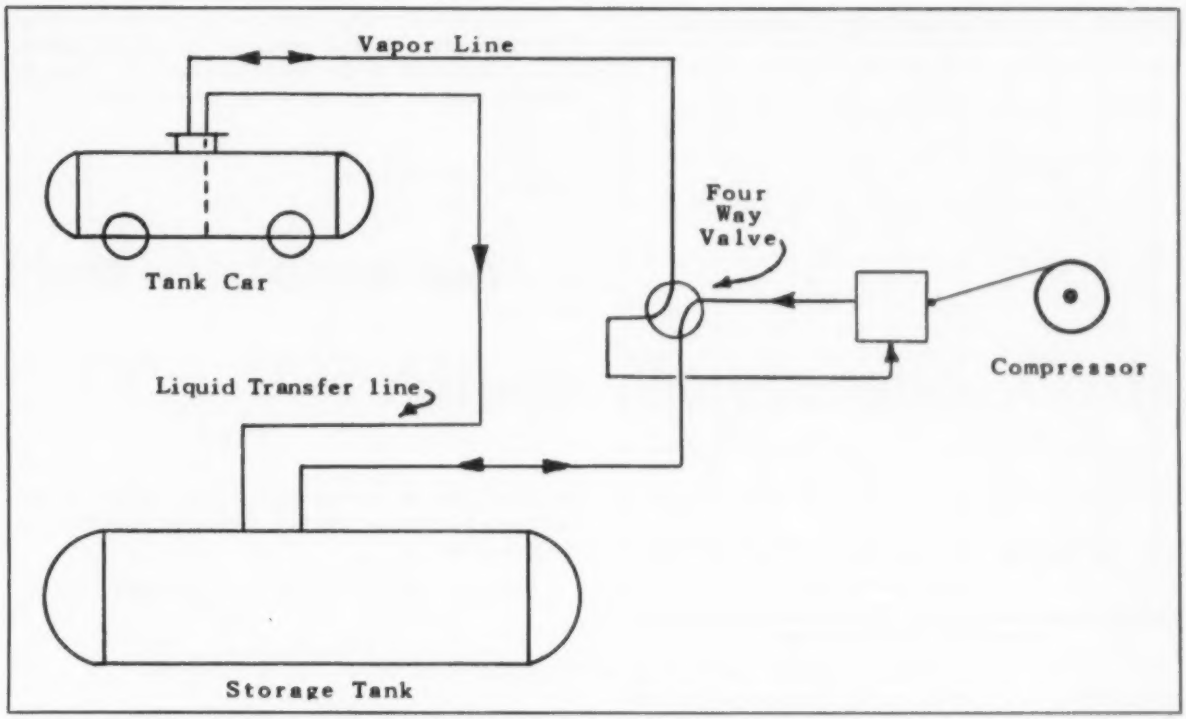


FIGURE 1—The four-way valve allows displacement of liquid propane from tank cars and then pumping of tank car vapor to storage tank.

How to Size an Unloading Compressor

Use this method for quick calculation of maximum horsepower required and depressuring time.

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HERE IS A rapid method of sizing a propane unloading compressor. It establishes the capacity and the maximum horsepower required to discharge the contents of a propane tank car within a given length of time. The method also may be used for numerous other cases where similar conditions prevail, such as the design of vacuum compressors.

The system under consideration consists basically of the equipment shown in Figure 1. The compressor is first used to compress vapor from the storage vessel to displace the liquid propane in the tank car. Since the vapor space in the tank is relatively small, this process takes little time and the liquid may be rapidly displaced from the tank car.

After the liquid has been removed from the tank car the four way valve is reversed and the compressor is used to pump the vapor from the tank car into the storage tank. A tank car at 150 pounds per square inch gage pressure will hold about 400 gallons of propane, which can be recovered by this procedure.

The compressor should be of sufficient capacity to depressure a tank car within a reasonable length of time. Assume a tank car of V gallons capacity, and a compressor with a capacity of v cubic feet per minute. Because the pressure range through which the compressor must operate is limited, it may be assumed that the volumetric efficiency of the compressor will remain reasonably constant. The rate of vapor removal from the tank car may be expressed in pounds per minute by multiplying the volumetric rate by the gas density ρ. The gas removed in time θ will then be $\int \rho v d\theta$

The amount of vapor removed from the tank car is

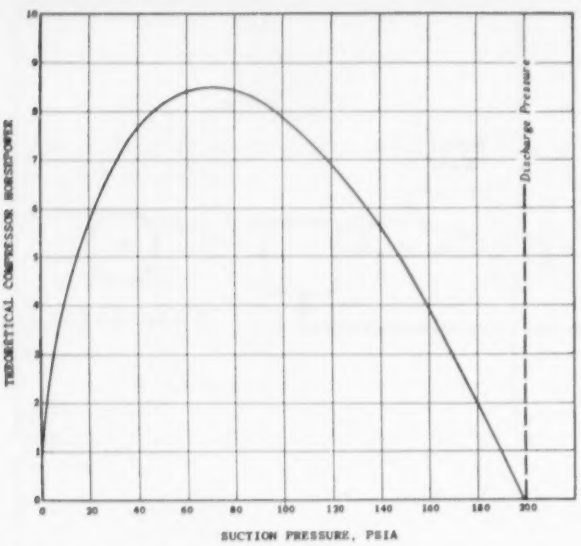

FIGURE 2—Variation of theoretical compressor horsepower with suction pressure when compressing propane.

equal to V $(\rho_1 - \rho_2)$. This may also be expressed as the differential expression.

$$\text{gas removed} = -\int V\, d\rho$$

Equating the two expressions

$$\int \rho v d\theta = -\int V d\rho \qquad (1)$$

Integrating this equation we have

$$\theta = \frac{V}{v} \ln \frac{\rho_1}{\rho_2} \qquad (2)$$

This relationship permits easy calculation of the time required to depressure a propane tank with a compressor of a given capacity.

For example, calculate the time required to depressure a 1000 cubic foot tank from 200 psia to 40 psia using a compressor with a capacity of 25 cfm

ρ_1 200 psia = 1.89 lb./cu. ft.
ρ_2 40 psia = 0.333 lb./cu. ft.

$$\theta = \left(\frac{1000}{25}\right) \ln \frac{1.89}{0.333} = 70 \text{ minutes}$$

The horsepower required to pump propane gas from a vessel varies as the suction pressure decreases, passing through a maximum at some mid point in the process. To determine this maximum horsepower it is necessary to consider the equation defining the theoretical work of a single stage compressor, i.e.

$$Hp = \frac{.00436\ K\ P_1 v}{K-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{K-1}{K}} - 1\right] \qquad (3)$$

where $K = C_p/C_v$
P_1 = suction pressure, psia
P_2 = discharge pressure, psia
v = compressor capacity, cfm

Assume the discharge pressure P_2 remains constant. This assumption is valid, when the size of the receiver is large compared to the size of the tank car. Then by differentiating the equation we get the expression

$$dHp = \frac{.00436\ Kv}{K-1}\left[\frac{\left(P_2\right)^{\frac{K-1}{K}}\left(1 - \frac{K-1}{K}\right) - 1}{\left(P_1\right)^{\frac{K-1}{K}}}\right] dP_1 \qquad (4)$$

and rearranging, and setting the expression $\frac{dHp}{dP_1} = O$ we obtain

$$\frac{dHp}{dP_1} = O = \left(\frac{.00436\ Kv}{K-1}\right)\left[\frac{\left(P_2\right)^{\frac{K-1}{K}}\left(1 - \frac{K-1}{K}\right)}{\left(P_1\right)^{\frac{K-1}{K}}} - 1\right] \qquad (5)$$

By substituting in this equation we may solve for the maximum horsepower required of the compressor in the example above.

$$O = \frac{(0.00436)\ (1.133)\ (25)}{(0.133)}\left[\frac{(200)^{.1172}\ (1 - .1172)}{P_1^{.1172}} - 1\right] \qquad (6)$$

$$O = (0.93)\left[\frac{(1.862)\ (.8828)}{P_1^{.1172}} - 1\right] \qquad (7)$$

$$P_1^{.1172} = 1.645 \qquad (8)$$

$$P_1 = 69 \text{ psia} \qquad (9)$$

The theoretical horsepower required at this condition is

$$Hp = (0.93)\ (69)\left[\left(\frac{200}{69}\right)^{.1172} - 1\right] \qquad (10)$$

$$= 64.2\ [1.133 - 1] \qquad (11)$$

$$= 8.5 \qquad (12)$$

Allowing for the compressor inefficiency and the motor loss, a 10 horsepower motor would be suitable for this service. Figure 2 is a plot of the variation of theoretical compressor horsepower as a function of the suction pressure for the compressor in this example.

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Meet the Author

E. L. GHORMLEY has been designing plants for the petroleum-processing industries more than ten years. Principally, this experience has been in petrochemical facilities, including those for producing ammonia, butadiene, acrylonitrile, polyethylene and phthalic anhydride. With The Fluor Corporation, Ltd., Los Angeles, since 1952, he previously was with The Girdler Company. He also has served George Armstead, Jr., and California Research Corporation. Ghormley holds a B.S. degree from Washington State University (1944) and a M.S. from Massachusetts Institute of Technology (1947).

How Automation Affects Maintenance Costs

Here are:

- **Five areas in which automation influences maintenance costs.**
- **Factors to be considered in holding these costs at their just level.**
- **Valuable tips for any operation planning to use automation.**

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THE EFFECTS of automation on maintenance cost have grown in prominence—particularly where the employment of recently developed techniques appear eminent.

Notable in this respect is equipment for scanning and logging, calculating, alarm detection, programmers, stream analysis, etc. as is required for an information system.

The instrument technician, as well as management, confesses concern over the maintenance and service of these devices. There is just reason for this apprehension. The average company is using or anticipating the use of this new class of equipment for the first time.

The new techniques of gathering information represent a new way of doing things and performing acts that have not before been possible. The instrument technician is faced with learning about these new devices. His comprehension and proficiency at servicing and repairing will appear slow by comparison to his abilities at servicing conventional pneumatic and electrical instrumentation.

This period of transition must be faced. During this period of time it may be best to contract for service from those equipped to manage such a program or from the manufacturer of this equipment. Some of the smaller facilities are finding this highly desirable for their conventional instrumentation and it is conceivable that this approach will increase in desirability with the increase in density and complexity of these new devices.

The prime purpose of this article is to point out the areas having effect on maintenance cost and those matters which must be considered in making an attempt to hold these costs at their just level. In summary, advance considerations of this subject should be in the following areas:

Design and Specifications

• **Instrument design and specifications** should have as a major consideration the maintenance cost factor. The several considerations that will tend to hold instrument maintenance costs at the normal or below normal cost bracket are as follows:

1. Proper Instrument and Equipment Selection
2. Design for Automatic or Manual Operation
3. Material Specifications
4. Instrument Supply Air and Electrical System Design

Instrument and equipment selection should receive its first consideration on the basis of reliability. Old line instruments and equipment reliability can be based on maintenance records that show frequency of service and replacement of parts.

New line instruments reliability, such as data reduction, logging, tape recording equipment, etc. as used in information systems can be based on the number of component parts, sim-

plicity of design and simplicity of service. These considerations, along with first cost, should influence equipment selection.

Design for automatic or manual operation should be such that component failure will not cause serious interruption of product quality and production. To accomplish this, consideration should be given to manual control through the use of by-passes around control valves and valve positioners, manual operators on solenoids, local indicators for transmitters, test wells adjacent to temperature tops, pressure taps adjacent to pressure transmitters, plug-in components, etc. In so doing, the design provides the flexibility that may spell the difference between successful operation or shut-down during times of instrument failure.

Materials specified for those parts exposed to the process stream should be determined on the basis of longevity versus cost, rather than first cost or risk only. Like consideration should be given those parts exposed to severe corrosive ambient conditions.

The instrument air supply system has frequently been the most neglected factor in system design. There are today concerns engaged in the enterprise of making air drying systems. These concerns recommend, and rightfully so, parallel drying towers or parallel units to insure dry air in the event of power failure or the failure of any components in the drying system.

Electrical installations also require careful planning and layout to ease the burden of trouble shooting and to provide protection from damage due to heat, water, oils, and physical abuse.

Installation

• **Rigid installation practice and specifications** will aid tremendously in reducing the maintenance costs. Consideration should be given to location and mounting of instruments at eye level for service, providing cat walks around remotely located control valves and transmitters, protection of liquid devices from freezing, providing easily serviced terminals for both electrical and pneumatic leads, utilization of non-metallic or alloy tubing in corrosive atmospheres, and protection from wind, rain, sun, and freezing.

Training of Operators

• **Training of the Operator** to operate his instrumentation brings to our attention another cost factor. With the increasing application of instrumentation the operator becomes faced with the use of tools that have not before been a part of his experience.

Operators are assigned areas with the authority and responsibility of managing all of the equipment contained therein. Because of this, their training must necessarily include instrument operation so that they not only know the technique of improving quality and production with these facilities, but also that have definite ideas with regards to its meaning and its limitations.

The new techniques of information gathering enable operators to make decisions that before have taken the form of conference activities.

Let's take, for example, a complete information system that includes among its features a means of determining the efficiency of various pieces of process equipment and over-all facility performance.

Here the operator can make maximum utilization of equipment before shutting down or swinging over to the spares. He is now assisting the cause of maintenance by using equipment to the point of diminishing returns and by spending maintenance money only when it will definitely pay off.

Other very useful and practical maintenance benefits are gained by operator training. For example, if he is trained to think in terms of control loops, he can adequately analyze these loops and be of valuable assistance in reducing the instrument technician's time required to think through the problem and pin-point the fault.

The operator should be prepared to answer basic questions and be prepared to present complete symptoms that are so necessary to expedite the repair of control loop components.

Further, the operator's ability to make an analysis of his loop will permit him to evaluate the reasonableness of requesting overtime, call-outs, etc. It may be that his own efforts are inconvenienced by the appearance of an inoperative device, but this can be insignificant compared to the cost of repairs at inopportune times when shop facilities are loaded or when the required shop complement is off-duty. Frequently, he may not be aware that such repairs require the call-out of pipefitters, electricians, or machinists in addition to the instrument technician.

Training of Technicians

• **Training of the instrument technician** and the extent of this training affect the maintenance cost ledger. With training and ability, maintenance efficiency is improved by virtue of proficiency and faithfulness to the art of instrument repair and calibration.

The accelerated growth of instrumentation has created a shortage of personnel trained to fill the needs of this field. Because of this, moneys must be appropriated at the early stage of new facility additions for the training of new personnel and the training and promotion of senior personnel. Upon completion of the facilities, appropriations are necessary for the continuance of a training program.

In the interest of developing a feeling of responsibility, "instrument operator" might be a better term for the refinery area instrument technician. In so doing, it would be easier for this man to develop the feeling of having the authority and responsibility for assuring continued opera-

Meet the Author

LOUIS G. GOOD, as senior project engineer in the Instrument Services division of Panellit, Inc., is concerned with instrumentation studies and the design, installation and startup of instrument systems. With the company since 1951, he previously was an assistant plant instrument engineer for Celanese Corporation of America. He was with that company three years and before that served Hercules Powder Company. Good is a mechanical-engineering graduate from Virginia Polytechnic Institute.

tion of the automatic devices under his care.

An instrument technician's capabilities at operating are another asset in the reduction of maintenance costs. This may seem odd at first notice, but the instrument technician should be the best "operator" in his area. Unless he has been trained or has trained himself to operate, his understanding and grasp of the system will impair his ability to analyze the operation and cope with the complaints logged against instrumentation.

Without operating knowledge he may waste labor and material in making alterations, seemingly repairs, etc. at the dictates of operating personnel. With training in operation, the instrument technician should then be able to spend his time and energies to the best interest of the operation and keep pure maintenance costs at their just level.

The first cost associated with the training of the instrument technician as an operator should reap rewards by reducing maintenance costs and by improving the product quality and production in his area.

Maintenance Program

• **The maintenance program,** its adequacy and enforcement, has its effects on maintenance cost. First, a budget must be established on a sound and all inclusive basis. This budget should be one that has considered the requirements of:

1. Maintenance Records and Administration
2. Preventative Maintenance Programs
3. Outside Service Contracts
4. Revamping Programs
5. Research and Development
6. Training Programs
7. Shop Facilities
8. Area Facilities
9. Spare Instrument and Valve Assemblies
10. Spare Parts for Instruments and Valve Assemblies
11. Spare Installation Material
12. Engineering and Drafting Complement
13. Instrument Shop Complement
14. Field Instrument Complement
15. Transportation
16. Communications
17. Participation in Professional Activities
18. Inner-Plant Visits and Conferences

However good the plan of maintenance may be, it will be no more effective than the method used for accumulating data and programming it. The very same techniques employed for process analysis, scheduling and programming may be the best solution to preserving a good maintenance plan and insuring its effectiveness.

Second, the maintenance program should be confined to certain categories of work. All too often the Instrument Department's responsibilities include categories of work remote from plant automation and in so doing add a disproportionate burden on the cost of instrument maintenance. Instrument Department responsibilities normally include:

1. Process and Power Instrumentation
2. Annunciator Systems
3. Data Reduction and Logging Systems

Categories of work remote from plant automation frequently include:

1. Scales for weighing
2. Time clock and watch repair
3. Typewriter and other business machine repairs
4. Air conditioning
5. Heating and ventilating
6. Water coolers
7. Calibration of shop precision tools, such as micrometers, etc.
8. Laboratory analytical instruments—scales, vapor testing devices, pH meters, viscositometers, knock machines, color testing equipment, mercury columns, recording thermometers, ovens, etc.
9. Refinery lighting controls
10. Intercom systems

Third, the consideration and function of other shop trades used to support the Instrument Department efforts bear consideration. The costs of instrument maintenance normally by records include the labor and material expended by the Instrument Department.

However, to be truly representative, the cost of automation should show other participating trades, such as piping, electrical, painting, welding, and the machine shop, labor plus the associated material. Advance planning for maintenance should include facilities for the above trades in their activities in automation.

Fourth, the control and scheduling of preventative maintenance, record keeping, evaluation of instruments and devices is perhaps the key to successful cost control. The budget can be adequate, the equipment can be the best, the personnel can be above average in competence, and all other factors may favor the costs of automation.

However good the plan of maintenance may be, it will be no more effective than the method used for accumulating data and programming it. The very same techniques employed for process analysis, scheduling, and programming may be the best solution to preserving a good maintenance plan and insuring its effectiveness.

Automation and the design of it for trouble free operation requires its share of thought and care. The absence or presence of such will have its lasting effect on maintenance costs. Automation also has its effects in reducing the degree of maintenance requirements in certain classes.

Automation is not commonly thought of as a means for improving maintenance costs, but its very nature is such that it can do just that. Let's consider the manual and batch operation versus the automatic and continuous one.

The large storage, mixing, and retention tanks are no longer required, nor is the maintenance such as patching, painting, cleaning, millwright, and electrical associated with them.

What maintenance manager will argue against continuous operation versus sporadic operations of equipment such as pumps, gear reduction units, conveyors, and valves? The point is—automation will lead into a design that favors continuously operating equipment and, therefore, equipment with optimum capacity.

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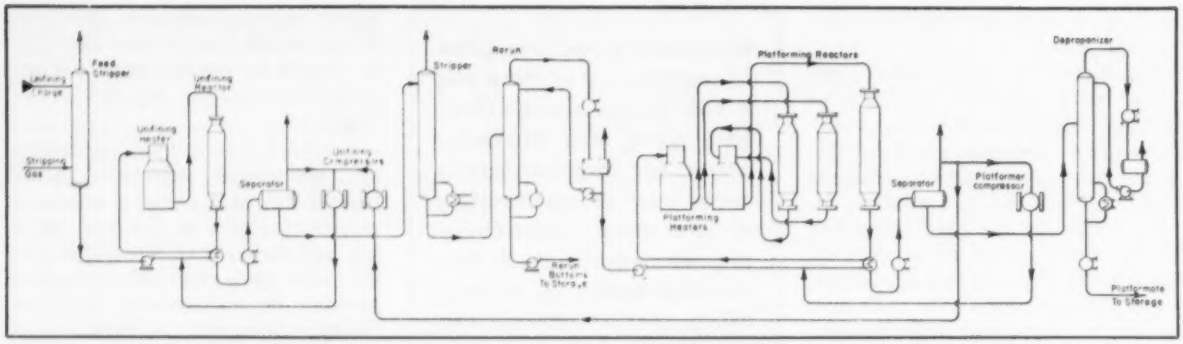

FIGURE 1—Flow diagram of Unifining-Platforming unit, Tide Water Associated Oil Company, Avon, Calif.

Unifining-Platforming in One Unit

More economical construction and operation is achieved by combining a Unifining unit with a Platforming unit.

C. F. Gerald
Universal Oil Products Company, Des Plaines, Ill.

ONE OF THE first units to have a Unifining section physically combined with a UOP Platforming unit is on stream at the Tide Water Association Oil Company at Avon, Calif. The unit gives the economies that go with mutual construction and operation. At the same time the two sections may be operated independently upon unrelated feed stocks.

The Unifining process has a great deal of popularity. Twenty-one units have been put into operation employing the process licensed by Universal Oil Products Company and Union Oil Company of California, since the process was announced less than two years ago.

The majority of the Unifining installations pretreat feed stocks to Platforming units. They convert submarginal feeds into highly desirable charges which have generally improved reforming response in terms of yields and octane numbers. They also remove some materials which are harmful to Platforming catalyst life.

Unifining operation at the Tide Water refinery demonstrates the success with which a saturated product is produced, essentially free from sulfur and other contaminants, from a blend high in organic sulfur compounds, olefins and metallic contaminants, basic nitrogen compounds, olefins and metallic contaminants. The product of this particular Unifining unit is subsequently fractionated into a stable stove oil (kerosine) fraction and a naphtha. The Platforming unit then upgrades this naphtha fraction into a premium quality gasoline of over 95 Research octane number.

Typical charge and product inspections for the Unifining and Platforming operations are given in Table 1.

Meet the Author

C. F. GERALD is assigned to Universal Oil Products Company's Engineering and Development department. With the department since 1951, he is engaged in coordinating and correlating commercial and pilot-plant data with engineering and design. His background includes four years as assistant professor of chemical engineering at the University of Washington, five years in UOP's Research and Pilot-Plant operations and a two-year stint as a research engineer for R. R. Donnelly & Sons Company. A graduate of Iowa State College, he holds a master's degree from the University of Cincinnati and a Sc.D. degree from Massachusetts Institute of Technology.

It should be noted that the process reduces appreciably the sulfur, nitrogen, and arsenic content of the charge.

The charge to Unifining is first stripped of oxygen with a portion of the hydrogen-rich vent gases produced in the unit. The charge pump takes suction from the bottom of the oxygen stripper and sends the feed through heat exchange to the heater. Recycle gas from the Unifining separator plus make-up hydrogen is injected into the charge just ahead of the preheater.

The mixture of vaporized naphtha and hydrogen, at 500 to 750 F. and 500 to 800 pounds per square inch, next contacts the catalyst, over which the desired reactions occur. The reactor effluent, now at a somewhat higher temperature than originally, due to the exothermic reactions which characterize the process, provides preheat to the Unifining charge. The cooled, condensed effluent then is separated from the gaseous product.

The hydrogen required to support the reactions occurring during Unifining is provided from excess Platformer gas. At Avon, the hydrogen is brought to Unifining unit pressure by a booster compressor separate from the compressor supplying recycle gas to the Platformer.

Separator liquid is freed of H_2S and light gases in a stripping column. In

order to maximize recovery of butanes, these gases are sent to an absorption system, not shown. The stripper liquid is next rerun, the products from this column being Platformer charge and stove oil.

The charge to the Platformer section is rerun column overhead product and recycled Platformer separator gas. The mixture is heat exchanged against reactor effluent, then brought to operating temperature in a furnace. The charge is reheated after passing through the first reactor because the Platforming reactions are predominantly endothermic. After passing through the second reactor, the hydrogen-hydrocarbon mixture is again reheated and passed through a final reactor so that the reforming reactions will reach the desired degree of completion.

The Platformate is cooled, condensed and sent to a separator, with the gas from this vessel being recycled to the Platforming reactors. Excess gas is used for Unifining, and additional gas beyond these requirements is vented to fuel. The separator liquid is stabilized by fractionation in the depropanizer, from which finished Platformate goes to storage for premium motor fuel blending.

Considerable savings have resulted from designing the two units as parts of a single plant, notably by common sparing of pumps and by reducing operating manpower requirements with a common control house. At the same time, flows of materials in the two sections of the plant have been deliberately kept separate to provide greater flexibility of operation. In this way it is possible to operate as two separate refinery units, using the Unifining unit to process materials, such as diesel oils, catalytic cycle oils and the like, which would not be charged to the Platformer. At such times the Platformer charge would be drawn from stored naphthas after Unifining or other naphthas not requiring this pretreatment.

The operations of this combination Unifining-Platforming unit are of particular interest because test data are available at intervals over a considerable period of catalyst service. Data at various periods up to 50 barrels per pound for the Platforming catalyst are shown in Table 2.

Excellent performance was maintained at both the Unifining and Platforming sections of the plant. This is evidenced by the constant high degree of purity of Unifining product and its consistently high yield of 100 volume percent, and by the continued high yield of Platformate. The first test was a preliminary run at a time when the unit was not being operated for as high an octane number product as in later tests.

While the charge stock composition was held nearly constant throughout these tests, the somewhat lower boiling point of charge stocks used in the later tests is responsible in part for the slight reduction in yields. With identical charge, yields would have been even more steady than are shown. This same difference in feed stocks is in all likelihood responsible for differences in Reid vapor pressure of the product and would tend to lower the hydrogen content of the gases evolved from the product separators.

It is important to note that the data in Table 2 are on an observed recovery basis and have not been corrected to 100% recovery as is customary. Correction to a no-loss basis would make the yield picture appear even more favorable for the performance of this unit. In addition, no transference of normally liquid materials which actually were carried from the unit in the gaseous streams has been made.

The Unifining-Platforming unit at Tide Water is one of the many which confirms the success of this type of operation. Operating data from all other installations also demonstrate that the advantages of Unifining are being fully realized in commercial operations. However, the Tide Water plant does illustrate nicely the range of problems which can be met by Unifining reformer feed stocks and the capacity of the process to eliminate simultaneously the deleterious effects of high sulfur, metals, organic nitrogen, and high olefins contents.

In addition to the application of Unifining to Platformer feed-stock preparation and upgrading of kerosines, commercial results from units desulfurizing gas oils show that the Unifining process produces fuel and diesel oil products of superior characteristics which can be marketed more profitably. The saturation of catalytic cycle oil can be particularly of merit when this material will be further cracked. Thermal gasolines and distillates may be improved similarly.

##

TABLE 1—Typical Charge and Products Inspections

	Unifining Unit			Platforming Unit Product C_4+
	Charge Stock	Stove Oil Product	Naphtha Product	
Gravity, °API	50.4	41.2	53.3	48.1
ASTM Bromine No.	28.0	0.9	0.7	1.5
Total Sulfur, Wt. %	0.660	0.0029	0.0025	0.0008
Mercaptan Sulfur, Wt. %	0.072	0.001	Nil	Nil
H_2S, Wt. %	0.014	Nil	Nil	Nil
Basic Nitrogen, ppm	49.0	2.4	0.3	
Total Nitrogen, ppm	62.0	6.4	0.5	
Arsenic, ppb	55	<1	<1	<1
Saybolt Color	—16	15	30+	
Research Octane				
Clear	56.6		49.2	84.9
3cc TEL	68.6		73.1	95.4
ASTM, Distillation, D86-54				
IBP, °F	160	399	178	120
10	236	403	234	194
30	272	406	264	250
50	298	410	288	282
70	329	415	314	314
90	372	431	348	355
E. P.	425	506	390	418

TABLE 2—Test Run Results—Unifining—Platforming Unit

Platformer Cat. Life, B/Lb.	12.9	16.4	41.2	50.3
Unifining Cat. Life, B/Lb.	8.9	11.9	21.2	28.2
Unifining Charge, B/D	10,703	10,968	10,534	10,693
°API	49.7	50.7	53.4	51.1
IBP	178	152	151	171
10	248	236	221	242
50	304	299	278	302
90	371	374	350	360
E.P.	419	422	402	408
Wt. % Sulfur	0.58	0.58	0.55	0.47
Bromine No.	21	24	23	20
Nitrogen, ppm	50	55	36	34
Unifining Liq. Prod. recovered, B/D	10,730	11,012	10,522	10,692
Vol. % yield	100.25	100.40	99.89	100.00
% Desulfurization	99.55	99.47	99.48	99.34
Rerun Overhead				
°API	51.9	53.4	55.4	53.4
IBP	199	170	156	175
10	250	236	218	239
50	298	290	274	292
90	363	352	337	348
E.P.	410	390	380	383
Wt. % Sulfur	0.003	0.004	0.003	0.003
Bromine No.	6.7	1.0	0.6	0.45
Nitrogen, ppm	1	Nil	0.5	Nil
Platformer Charge, B/D	10,150	10,250	10,133	10,115
C_4+ Platformate recovered, B/D	9,548	9,391	9,322	9,316
Vol. % of Platf. Chg.	94.1	93.5	92.0	92.1
Wt. % of Platf. Chg.	96.6	94.2	93.7	93.0
Inspections				
°API	47.1	48.3	52.6	50.5
IBP	136	129	111	106
10	220	188	170	174
50	296	280	264	280
90	368	358	344	358
E.P.	436	426	408	421
RVP	3.9	3.8	6.7	6.1
Octanes				
F-1, clear	80.4	84.4	84.4	84.6
F-1, +3cc TEL	92.8	95.2	95.3	95.2
Miscellaneous				
Wt. % Recovery in Test	100.3	99.1	99.9	99.5
H_2 Content, Platf. Sep. gas	92.9	93.5	89.2	88.4
H_2 Content, Unifining Sep. gas	94.4	94.2	91.6	91.5
H_2 Consumed in Unifining, SCF/B	237	238	230	264
H_2 Produced in Platf., SCF/B	911	882	684	716

The Dollar Value of Human Relations

Successful human relations means efficient and low-cost maintenance. Here is a sound program that will fit into any operation.

J. O. Thoen
Continental Oil Company, Ponca City, Okla.

GOOD PERSONNEL relations in maintenance work are not a burden to management. It is true that there is required more planning, more training, plus better organizing and supervising. However, measures necessary for attaining good personnel relations are the very ones required for efficient and low-cost maintenance.

In other words, *good human relations make money.*

To solve the human relations problem, additional measures are needed which would not otherwise be a part of the work efficiency program. Both the normal and the less common psychological human manifestations must be taken into account. Some experts classify these into the logical and the nonlogical, but they are in a sense all logical since there is somewhere in the background of the individual a reason for the way he acts and feels.

In the maintenance division of a large oil refinery, there are generally four main groups whose work must be coordinated. These are the operating, mechanical, inspection, and safety sections.

Other maintenance units include corrosion, process, and industrial engineering. Since all play an important role in the maintenance program, the possibilities of friction between groups and individuals can be serious.

In any maintenance project, the planning of work must include consideration of human factors. One common source of trouble is the assumption, or what is thought to be such, of the functions of one group or individual by another. Even if there is no adverse effect on the work, the resentful feeling is there. Once aroused, such a feeling on the part of either a group or an individual will lead to suspicion and antagonism under much less provoking circumstances.

Another cause for conflict which arises occasionally is where an operating supervisor may have special experience with a particular mechanical problem. Without giving the background of his knowledge, he may try to prevail on the mechanics to change their methods after the work is in progress. The mechanics will naturally regard this as an unwarranted intrusion.

Human conflicts are inevitable in any operation, but they affect over-all efficiency.

Knowledge and acceptance of group functions is the logical starting point. Its importance is often underestimated. Each group and each individual in the group must know their duties and responsibilities and also those of other groups in the maintenance division. Overlapping of responsibilities should be avoided and functions clearly and thoroughly defined. Department members should be trained and encouraged to ask supervisors for interpretations of functions, if necessary. This affords one of the best means of improving company policies.

The operating and mechanical sections are line organizations, whose functions are fairly clear cut. With respect to maintenance, however, there may be rather wide differences in the policies of different companies or even in the policies of different departments in the same company.

In Continental Oil Company, the responsibility for expenses lies with the operating section. The operators decide what maintenance shall be done and when. The mechanical section assists them through a preventive maintenance program and in some plants by assigning staff engineers to areas. All mechanical work is strictly under the control of the mechanical section. No one in the operating section may direct or supervise the mechanical craftsmen. Thus, the mechanical unit is exclusively responsible for the quality of its work and for the efficient use of its man power.

Some organizations may have a different policy. Management may give all of the responsibility to the maintenance engineer for keeping the equipment in good operating condition. Such a system would, of course, give the engineer a freer hand in planning his work and improving its efficiency. On the other hand, he may be under considerable pressure to reduce the over-all maintenance costs, and he would be inclined to omit or postpone jobs which the operators think should be done.

Here again the proper foresight reflected in training and standards can go a long way to prevent personnel relations difficulties. In this case a set of maintenance standards is a most necessary organization tool. Such standards will dictate what must be done under any conditions of maintenance requirements.

The inspection and safety groups are staff and not line organizations. Their functions must be written as carefully, if not more so, as those of the line because they are more likely to be misunderstood. In Conoco's maintenance division, staff does not mean merely "advisory" in the usual sense of the word. Our maintenance staff groups have no authority over the operating and mechanical people, but they do have the authority of information. They find and report facts which are the basis for the line organization's operations.

The inspection section functions according to the codes and standards outlined in company policy. Their inspection data reveal what must be done in order to comply with these standards. There may be border-line cases where the inspectors make precautionary recommendations. But when they say a certain replacement should be made, it is mandatory and

made so by policy and not by the inspectors.

The same principle applies to the safety staff. Management decides what safety measures shall be taken. The safety men make the necessary inspections and tests to see that these precautions are taken according to the rules—and sign the necessary permits for the work to proceed. Again this is information—authority lies in the policy.

If these principles are understood thoroughly, inspectors and safety men will have little difficulty with the line groups as long as they operate within the scope of their prescribed functions. There will, however, be trouble if they dictate policy or give orders. The inspectors should not tell the mechanics that they must do a certain job, or the operators that they cannot operate a unit until it is mechanically up to standard. For some reason, the operators may choose to operate a unit with substandard equipment. In such cases, they assume full responsibility for the departure from standard practice.

If management gives the inspection section full control of all the things involved in connection with inspections, there is immediately a duplication of functions. Under this arrangement the inspectors could become policymakers, designers, supervisors, purchasers, and storekeepers.

To be consistent, management would then give the safety staff similar authority in its line of work. This would give the men in that group the freedom to dictate safety measures, which conceivably could be extended to the point where it would absorb inspection functions. Handling the personnel problem under such a system would be a difficult task.

Carefully written definitions of functions, which are clearly understood by all division members, are the first essential to good human relations in maintenance. While function definitions tell us who shall do what, standard practices state when and how it shall be done. The interdependence of the two as management tools is obvious. Logically, the standards should be written first since to some degree they must be taken into account when defining functions.

Standard Practices—There are several categories of standard practices, including standard operating procedures covering detailed instructions for starting, controlling, and shutting down equipment. The basic objective is operating efficiency and safety, accomplished with the minimum of friction and confusion.

To make operating procedures effective, the operating personnel should be consulted and given a hand in their preparation. This helps establish better working relationships and eliminates differences of opinion.

In the mechanical section, standard maintenance practices are extremely important. They should state under what conditions, and how, a repair job should be done. The inspection section takes care of a large part of this by the application of the various national and company codes, which specify safety or maintenance standards. But standards can be set for many other mechanical maintenance practices.

Last, a company should have equipment standards, which give the specifications for purchased or fabricated materials, machinery, and other equipment. In Continental, there are four types of standards by which the mechanical section is guided:

- Inspection schedules
- Equipment condition
- Materials and equipment
- Work methods

The standard practices and methods used by the equipment inspectors and safety inspectors do not involve too great a problem. They are necessary for good relations mostly within the group and between the groups, but they are not difficult to formulate because of the relatively simple mechanics of the work.

Planning—the third essential in an efficient maintenance program—includes several distinct activities. In a large maintenance organization, there may be required at least three specialized groups to handle it properly. The first group includes the designing or engineering. The second is the estimating of man hours and the sequence of job steps. The final planning function is scheduling.

Men, materials, and tools must be selected and transported to the job sites at the right time. If these plans do not materialize, the consequences are confusion, lost time, and lost tempers.

The best way of avoiding these disturbances is to incorporate in the planning program a procedure for checking everyone's plans well before the work begins. This can be done most effectively by having planning meetings attended by representatives of all groups.

Communications as a part of planning is essential, but it entails more than that. It is an indispensable tool for maintaining good human relations when plans for any reason do not work out or when new situations arise.

The original schedule should be written out and distributed to all concerned. Changes should be made for good reasons only, and the need for them should be communicated to everyone who collaborated in the original plan.

A fixed rule of procedure for such communications is not easily made. The decisions as to when and how to pass this type of information to others must often be left to the discretion of the supervisor. His decisions must be based on the knowledge of the situation and the feelings of the other fellow. It is not safe to assume that he would not be interested even if it may appear that it is none of his business. The fact that the communication might not result in any further change in plans is irrelevant, from the human relations standpoint.

Skill—Speaking now of the fifth major requirement, skill, there is little to say beyond the obvious. When an operator finds a job badly done, he is naturally put out at the mechanic. Or visa versa, when the mechanic finds that the operator has done a poor job in preparing the equipment for him. Delays and unpleasant reactions may then result.

A different type of problem presents itself in the case of trouble-breeding individual attitudes. Some people consciously or unconsciously do not get along with others. A supervisor could be faced with the problem of changing an attitude which may be an ingrained habit. A sound training and information program will help minimize the occasions for provocation. Organizing the work along the line outlined above should create an atmosphere of good relations. This will generally have a moderating effect on such personality problems.

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THIS METHOD recovers ash which is lost during most other determinations. A phthalic anhydride filter recovers ashes from combustion gases to bring about . . .

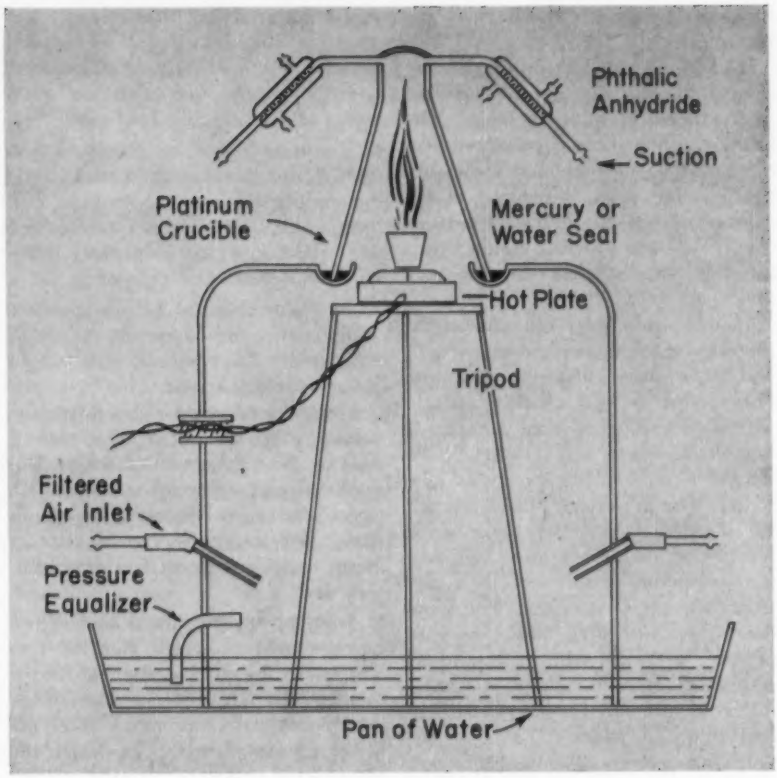

FIGURE 1

A Better Ash Determination

Philip W. West, West Louisiana State University, Baton Rouge, La.
Hans A. Suter, Celanese Corporation of America, Clarkwood, Texas
and Gerald Perkins, North Texas State College, Denton, Texas

PRESENT METHODS of ashing crude oil do not take into consideration any loss of ash which might occur during the ignition, or free-burning step which is common to all of them. This investigation demonstrates that metal atoms in organic molecules may be lost during the ignition. The ash recovered from the gases formed during the ignition step is identical in chemical composition with the ash remaining in the ignition crucible.

It may be inferred that the recovered ash came originally from the oil sample and represents an error in method for the existing procedures. Several samples of oil were checked and the lost ash was found to be so large that at no time could it be considered negligible.

With a phthalic anhydride filter apparatus, which was designed during the course of this investigation, the lost ash may be recovered. The apparatus was checked with synthetic samples and found to give an accuracy of better than 90 percent which was considerably better than the accuracy found for the existing methods.

Reproducible results may be obtained from most ash methods only if the necessary operations are conducted under rigorously controlled conditions. The essentials of most current methods are embodied in the method described in the A.S.T.M. Standards on Petroleum Products and Lubricants for 1947,[1] which is referred to hereafter as the ASTM method. A sample of oil weighing 20 ± 0.1 gram is heated in a tarred platinum crucible to the fire-point, ignited and allowed to burn freely until it has been entirely consumed. The crucible and the carbonaceous residue are then ignited at red heat (burner or furnace) to constant weight.

A modification of the ASTM method referred to as the "Standard Oil Method" employs a 100 gram

sample and the final ignition is carried out in a furnace at a temperature of 700 C. Webber[2] and Feigl[3] have described methods for ashing petroleum products which are similar to the ASTM method. Roberts, Stenzel, and Eberz[4] modified the ASTM method by carrying out the final ignition in the presence of sulfuric acid.

An evaluation of the errors inherent in the ASTM method has been made by Morgan and Turner.[5] They concluded that losses attributable to volatilization and entrainment of ash components are not of great significance in properly conducted analyses. Karchmer and Gunn[6] made a study of the factors involved during the ashing of crudes and refined products and proposed a method placing the emphasis on the sampling of the material and on the final ignition temperature.

Recently, Gamble and Jones[7] have proposed the wet ashing of petroleum followed by spectrographic analysis. Barney[8] has suggested an acid extraction procedure for isolating ash materials prior to spectrographic analysis.

In spite of all of these analytical precautions taken during the ashing, the results obtained often do not agree with the amount of inorganic material present in the petroleum. This is evidenced by the fact that petroleum products often deposit on catalyst beds of cracking units a greater quantity of metallic oxides than the anticipated amount based on the analytically obtained ash-value. This discrepancy becomes especially large when the product being cracked is not a crude oil but some previously distilled fraction.

This discrepancy may be explained by postulating the volatilization of ash constituents during the ash determination. Milner, Glass, Kirchner, and Yurick[9] have demonstrated that some metallic constituents are lost during the conventional ashing. Stable metal chelates would be especially susceptible to volatilization during ashing.

The presence of metal chelates is not surprising when the biological origin of petroleum is taken into account. Treibs[10] isolated porphyrins from a large number of petroleum crudes, and in the case of a shale oil demonstrated the presence of copper- and ferro-porphyrin complexes.[11] He was able to prove the existence of vanadium porphyrin complexes in crudes of different origins. Skinner[12] observed similar vanadium complexes in Santa Maria Valley crudes which averaged a vanadium content of 0.022 percent.

There are several known examples of chelates which are sublimable under certain conditions.[13,14,15] This is a drawback in analytical procedures which require the ashing of the metal chelate previous to weighing. In such cases volatilization of metal usually can be avoided if the ashing is done in the presence of oxalic acid[16] or ammonium formate.[17] In some cases, however, the ability of a chelate to sublime is used to advantage for its easy purification.[18,19]

Meet the Authors

PHILIP W. WEST is Boyd Professor of Chemistry at Louisiana State University. A 1935 graduate of the University of North Dakota, Dr. West took his master's degree there in 1936 and completed his doctorate at the State University of Iowa in 1939. Before joining Louisiana State, he served North Dakota Geological Survey, Iowa State Department of Health and the Economics Laboratory at Iowa State University. In 1940 he was made head of the Division of Analytical Chemistry at Louisiana State and in 1950 was made a full professor. In 1953 he was one of three faculty members elevated to the newly-created rank of Boyd Professor. In 1946, Dr. West was sent to Rio de Janeiro to collaborate on research in spot-test analyses and on the development of new organic reagents. He is originator and chairman of the annual LSU Symposium on Modern Methods of Analytical Chemistry, author of more than 90 articles, including two books and a patent.

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HANS A. SUTER is a research chemist with Celanese Corporation of America at Clarkwood, Texas, where he is engaged in petrochemical research. Before joining the company in 1954, he was an associate professor of chemistry at Rollins College in Winter Park, Fla. He holds B.S., M.S. and Ph.D. degrees in analytical chemistry from Louisiana State University.

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GERALD PERKINS is an associate professor of chemistry at North Texas State College in Denton. Previously, he taught physical and analytical chemistry at Southwestern Louisiana Institute and analytical chemistry at the University of Arizona. At North Texas State College, where he has been a faculty member since 1952, Dr. Perkins teaches analytical and electrochemistry. A graduate of Southeastern Louisiana College, he holds M.S. and Ph.D. degrees from Louisiana State University.

TABLE 1
Recovery During Ashing
(About 0.1 Weight Percent Ash Content)

COMPOUND	Weight of Compound (grams)	Weight of Oxide		Recovery (Percentage)
		Present (grams)	Found (grams)	
Al-oxine	.4052	.0449	.0325	72.5
	.4154	.0460	.0331	72.0
	.4125	.0458	.0368	80.3
	.4050	.0449	.0385	85.9
	.4062	.0450	.0363	80.7
	.4069	.0451	.0353	78.5
Fe-oxine	.2790	.0457	.0445	97.5
	.2855	.0468	.0460	98.3
V-oxine	.1805	.0492	.0303	61.6
	.1816	.0495	.0308	61.8
Cu-oxine	.2080	.0470	.0340	72.4
	.2175	.0492	.0312	63.5
	.2037	.0460	.0363	79.0
	.2043	.0461	.0367	79.6
Ni-oxine	.2260	.0473	.0454	96.0
	.2140	.0461	.0443	96.0
	.2023	.0435	.0420	96.5
Al (Acac)$_3$	.3010	.0470	.0364	77.4
	.2989	.0467	.0368	78.9
Fe (Acac)$_3$	.2112	.0483	.0435	90.0
	.2010	.0461	.0415	90.0
Cu (Acac)$_2$	.1504	.0457	.0323	70.7
	.1505	.0457	.0343	75.0
	.1520	.0462	.0351	76.0
	.1520	.0462	.0351	76.0
Ni (Acac)$_2$	.1711	.0436	.0428	98.3
	.1806	.0461	.0456	98.9
Cu-benzoinoxime	.1864	.0519	.0404	77.9
Cu-salicylaldoxime	.1905	.0532	.0410	77.2
	.1921	.0455	.0388	85.3
Ni-salicylaldoxime	.2000	.0474	.0389	82.2
	.1877	.0432	.0392	90.8
Ni-dimethylglyoxime	.1863	.0430	.0400	93.0
	.1745	.0450	.0422	93.7
	.1797	.0465	.0452	97.2
	.1758	.0454	.0424	93.4
	.1780	.0459	.0432	94.0
Hemin	.2006	.0237	.0232	97.9
	.2034	.0240	.0236	98.4
Al-oxalate	.1669	.0433	.0429	99.0
	.1739	.0451	.0441	97.8
Fe-oxalate	.1331	.0444	.0434	97.8
	.1357	.0455	.0446	98.2
Cu-oxalate	.0955	.0490	.0438	89.5
	.0967	.0496	.0453	91.1
Ni-oxalate	.1195	.0483	.0465	96.3
	.1159	.0467	.0454	97.0
Ni-malonate	.1475	.0558	.0562	101
	.1160	.0437	.0433	99.0
Cu-succinate	.1060	.0468	.0379	81.0
	.1132	.0500	.0402	80.5
Ni-succinate	.1775	.0520	.0535	103
	.1750	.0511	.0516	101
	.1756	.0514	.0515	100
	.1739	.0508	.0507	100
Cu-adipate	.1202	.0441	.0361	81.8
	.1279	.0471	.0397	83.8
Ni-adipate	.1532	.0427	.0426	100
	.1502	.0419	.0425	101

The relative volatility of various metal complexes were measured by an ash determination. A sample of each complex was prepared by weighing into a tared 100 milliliter platinum dish an amount of compound which would yield approximately 45 milligrams of metal oxide. To the compound, 5 milliliters of redistilled chloroform were mixed by swirling the dish. Then, 50 milliliters of paraffin oil were added slowly while swirling the dish continuously. The paraffin oil has a density of about 0.9 grams per

milliliter. Therefore, the mixture would have an ash content of about 0.1 weight percent.

The dish was then cautiously heated until all chloroform was removed. The heating was continued up to the fire-point of the paraffin oil. As soon as the oil was burning freely, the heat was removed and the oil was allowed to burn off. At the end of the combustion the platinum dish was placed in an electric muffle, heated to 500 C. and left there until constant weight was attained. The weight was found to be constant as soon as all carboniferous material had been removed. The platinum dish was then placed in a desiccator and after cooling was weighed. The results obtained are tabulated in Table 1.

The procedure was repeated for the innercomplex salts at a lower concentration. The results for ashing of samples containing 0.02 weight percent metal oxides are presented in Table 2.

TABLE 2
Recovery During Ashing
(About 0.02 Weight Percent Ash Content)

COMPOUND	Weight of Compound (grams)	Weight of Oxide		Recovery (Percentage)
		Present (grams)	Found (grams)	
Al-oxine	.0844	.0094	.0093	99
	.0841	.0093	.0091	98
Fe-oxine	.0550	.0090	.0090	100
	.0557	.0091	.0087	96
V-oxine	.0531	.0144	.0102	71
	.0531	.0144	.0101	70
Cu-oxine	.0421	.0095	.0073	73
	.0450	.0102	.0080	78
Ni-oxine	.0430	.0093	.0090	97
	.0420	.0090	.0089	99
Al $(Acac)_3$	.0600	.0094	.0100	106
	.0594	.0093	.0090	97
	.0611	.0096	.0102	106
	.0603	.0094	.0098	104
Fe $(Acac)_3$	.0428	.0099	.0090	91
	.0425	.0098	.0087	89
Cu $(Acac)_2$	.0301	.0092	.0048	52
	.0299	.0091	.0047	52
Ni-$(Acac)_2$	.0367	.0094	.0090	96
	.0371	.0095	.0095	100
Cu-benzoinoxime	.0329	.0092	.0088	96
	.0325	.0091	.0088	97
Cu-salicylaldoxime	.0377	.0089	.0044	50
	.0385	.0091	.0043	47
Ni-salicylaldoxime	.0395	.0091	.0082	90
	.0411	.0095	.0091	96
Ni-dimethylglyoxime	.0343	.0089	.0084	94
	.0354	.0092	.0090	98
Hemin	.0699	.0083	.0084	101
	.0690	.0082	.0086	105
Cu-prophyrin	....	.0152	.0154	101
	....	.0152	.0152	100

The results tabulated in Tables 1 and 2 indicate that the majority of innercomplex salts are volatile in high concentration, i.e., 0.1 weight percent. The iron porphyrin complex (hemin) and the iron 8-quinolinol complex lose very little during the ashing process and they can be considered nonvolatile. The salts of dibasic acids showed no volatility with the exception of the copper compounds. The situation changes for the innercomplex salts when we consider the results obtained with a concentration of 0.02 weight percent. Here most salts show no volatility and only the 8-quinolinol complexes of vanadium and copper and the copper complexes of salicylaldoxime and 2,4-pentanedione show marked volatility. Experiments have shown, however, that even the copper 2,4-pentanedione exhibits no volatility when ashed in a concentration of 40 ppm. (0.004 weight percent).

The precision of the results is not high and exceptional precautions would have to be taken to secure reproducible values. The data do show trends and are of value in establishing general information pertaining to the ash problem.

Coincident with these data the spectographic examination of residual ash and ash recovered from deposited soot which was carried out in a later phase of this work indicated that there is ash lost during the "free burning" process, that this ash is identical in chemical composition with the residual ash, and that the lighter elements have more tendency to be lost as fly ash than do the heavier elements. In speaking here of fly ash the term is used of necessity to include all ash carried away from the ignition crucible in any manner.

A study of present methods for determining ash was made. The ones used in this study were the ASTM, Standard Oil, and the infrared methods. The first two have been described previously. The infrared method used 100 grams of sample in a tared platinum dish. Two units of a Fisher Infra-Rediator are used, with one inverted to give bottom heat. This arrangement provides a temperature of approximately 180 C. The oil is evaporated as far as possible and the remainder burned away. The residue is ignited in a furnace at 700 C. for four hours, and the gain in weight represents the weight of ash in the sample.

The ASTM method required approximately 8 hours for a complete determination; the Standard Oil method, 6. This difference is apparently due to the increased surface area in the platinum dish. The total time required for the infrared determination was 56 hours, 50 of which were necessary for evaporation under the infrared lamps.

The infrared method is not satisfactory due to the fact that after approximately two-thirds of the oil has evaporated a crust forms over the surface, thus preventing further evaporation. When the crust is broken it quickly reforms. Further trouble is encountered in burning away the remaining oil which has a tendency to boil and expand under the crust, causing small eruptions which may push their way over the side of the crucible.

Two samples of oil were used in these tests. The results of the ignitions are presented in Table 3. The ASTM and Standard Oil methods give values of similar magnitude whereas the infrared method gives values which are somewhat higher than those of the other methods. These higher values which were obtained with the infrared method indicated that some ash might be lost during the burning period of the ASTM and Standard Oil methods.

TABLE 3
Comparison of Methods for Ash Determination
(Weight Percent Ash)

OIL A

A.S.T.M.	Standard Oil	Infrared
0.0361 0.0394 0.0456 0.0457 0.0470 0.0512	0.0374 0.0432 0.0477	0.0501 0.0507
0.0442 avge.	0.0427 avge.	0.0504 avge.

Overall average for all methods	0.0449
Average deviation	0.0043
Standard deviation	0.0051

OIL B

A.S.T.M.	Standard Oil	Infrared
0.0027 0.0016	0.0019 0.0021 0.0024 0.0025 0.0023 0.0030	0.0026 0.0029
0.0022 avge.	0.0024 avge.	0.0028 avge.

Overall average for all methods	0.0024
Average deviation	0.0003
Standard deviation	0.0004

The ash loss was traced by a simple investigation of the ignition process. A sample of oil was placed in one of the platinum dishes, similar to those used for the Standard Oil method, and was ignited at the surface and allowed to burn with a free flame. A clean, cold porcelain evaporating dish of large diameter was inverted in the flame. Soot deposited to a considerable depth on the surface of the dish. Periodically this deposit was removed carefully

from the dish and placed in a tared platinum crucible. Enough was collected to fill the crucible and the whole was weighed. The material was then ignited at 700 C. until the weight became constant. The ash which remained was weighed and the percentage of ash in the soot was determined. Two samples of *Oil B* yielded values of 0.10 percent and 0.13 percent for the ash content of the soot.

To establish the fact that this recovered ash was identical with the residual ash, a spectrographic examination was made. Samples of both residual ash and fly ash were analyzed with a large Littrow spectograph using a carbon arc as the exciting source. The samples were identical in composition with respect to the elements present, but it was noted that the relative proportions of the elements, as indicated by the line densities, varied in the two samples.

The analysis established the presence in both ash samples of the elements: vanadium, iron, nickel, lead, zinc, sodium, calcium and silicon. In the residual ash vanadium and iron were present in the largest proportion while silicon was present only as a trace. In the fly ash the calcium and silicon were present in the greatest proportion whereas the iron and vanadium were present in only a small amount. The relative proportions of the other elements were little changed in both samples.

New methods of ash determination were devised to retain the ash that was being lost by the previous methods. The principles which were used were as follows:

- Cottrell precipitation
- Liquid adsorption
- Enclosed combustion chamber
- Combustion gas filter

McClendon,[20] in a determination of iodine in ignition gases, employed a form of Cottrell precipitator with good results. Shreve and Welborn[21] employed a Cottrell precipitator to recover solid material from escaping gases. However, the apparatus used in the study reported herein became so fouled with soot that the power supply was shorted. Eventually the device was abandoned because of these experimental difficulties.

The next system was a liquid adsorption train. The ignition gases were drawn through a funnel-shaped hood and through various adsorption solutions. Lack of intimate mixing of the gases and the liquids, and the high original solid content of the absorption liquids caused the system to be abandoned also.

Check these references to see how the Innercomplex Salts may be prepared.

Innercomplex Salts	Reference	Metal Oxide Content
Aluminum 8 quinolinol complex (Al-oxine)	22	11.09%
Iron (III) 8-quinolinol complex (Fe-oxine)	23	16.35%
Copper 8-quinolinol complex (Cu-oxine)	24	22.60%
Nickel 8-quinolinol complex (Ni-oxine)	25	21.52%
Vanadium 8-quinolinol complex (V-oxine)	26	27.23%
Copper benzoinoxime	27	27.85%
Copper salicylaldoxime	28	23.68%
Nickel salicylaldoxime	29	23.00%
Nickel dimethylglyoxime	30	25.84%
Aluminum 2,4-pentanedione complex ($Al(Acac)_3$)	31	15.56%
Iron (III) 2,4-pentanedione complex ($Fe(Acac)_3$)	32	22.97%
Copper 2,4-pentanedione complex ($Cu(Acac)_2$)	33	30.44%
Nickel 2,4-pentanedione complex ($Ni(Acac)_2$)	34	25.49%
Iron-porphyrin complex (Hemin)	35	11.78%
Copper-porphyrin complex (g)	36	15.2 mg/25ml

The third system was an enclosed combustion chamber. In this system, the sample was forced through a small hypodermic needle by a mechanically-operated hypodermic syringe. The needle was surrounded by an oxygen tube so that the sample could be burned at the tip of the needle. Both needle and oxygen tube were enclosed in a glass chamber with a fritted glass exhaust port. In operation, however, the flame would cause the oxygen tube to soften and sag and extinguish the flame. This system was discontinued while a more satisfactory burner tip was sought.

The combustion gas filter gave the best quantitative results. Reagent grade phthalic anhydride was used as a filter medium. The filter units were charged as follows: a circle of ashless filter paper supported by a plug of cotton was placed over the lower, or exhaust, stopper; finely crushed phthalic anhydride was placed over the filter paper and above that, extending for a height of about five centimeters, was placed coarsely pulverized phthalic anhydride crystals. The whole assembly was mounted over the crucible and while the oil was burning a constant stream of air was drawn into the hood and through the system by means of aspirators. The volume flow through the units and the number of units utilized could be controlled by the aspirators. To insure condensation of the volatile ash a water jacket was placed around each filter unit.

After the burning process was complete the crucible which held the sample was removed and heated to constant weight in a muffle furnace at 700 C. and the ash value obtained was termed "residual ash." The phthalic anhydride and the ashless filter paper from the filter units (together with the soot deposit from the interior of the hood and connecting tubes) were transferred to a tared platinum dish and placed in an oven at 180 C. where the phthalic anhydride evaporated away. The crucible was then placed in a furnace at 700 C. and brought to constant weight. The gain in weight represented ash recovered from the ignition gases and was termed "fly ash" or "recovered ash." When the two ash values were added the total represented the true ash content of the oil.

This apparatus was first used to determine the ash content of *Oil B* one of the oils previously tested with the current ashing procedures. A comparison of three determinations is given in Table 4. These results were more than three times as large as those obtained by any other method. This represented quite an error for the previous methods if the ash-recovery method were to be considered correct.

TABLE 4
Analysis of Oil B

METHOD	Weight Percent Ash
A.S.T.M.	0.0022
Standard Oil	0.0024
Infrared	0.0028
Ash Recovery	0.0087

In the absence of any good method for checking the relative merits of the different procedures, it could be inferred that the one which could logically be shown to have the fewer sources of error would be the most nearly correct. To this end the apparatus was again modified in such a way as to form a "closed system" into which was introduced only filtered air. This removed the possibility of high results due to atmospheric dust.

The new apparatus consisted of the previously described hood and filter arrangement placed over a large, inverted beaker which was equipped with an opening in its bottom and several inlet tubes piercing its walls. The beaker was inverted in a pan of water, thus excluding the outer air completely, and enclosed within was

the tripod and ignition crucible. A hotplate was added to keep the oil burning as its level became low in the crucible and the wires to the hotplate were passed in through a packed inlet tube. The other inlet tubes served for the introduction of air which had been filtered through a glass tube, approximately 15 centimeters long, packed with glass wool which was kept wet with a heavy oil. The junction of the hood and beaker was closed with a mercury seal and a slight internal positive pressure was maintained at all times to insure that there would be no leakage of outside air. Cooling water was flowed over the outside of the beaker in order to prevent volatilization of the mercury from the seal. The apparatus is shown in Figure 1.

Natural and synthetic oil samples were analyzed by the ash-recovery method. The results for the natural oils are listed in Table 5. Since the residual ash figure is equivalent to that which would be obtained by the ASTM method, the three columns—residual ash, recovered ash, and total ash—give a picture of the difference in results obtained by the two methods. average values have been listed in this table. Samples 1 and 4 were run four times. Samples 2, 3, and 6 were each run three times. Sample 5 was run only once. All determinations on the same oil checked within 5 ppm. on total ash. The error due to fly ash was indicated to be large and was apparently at no time small enough to be disregarded.

TABLE 5

Ash Content of Oils by the Ash Recovery Method

Sample	Residual Ash (ppm)	Recovered Ash (ppm)	Total Ash (ppm)
1	24	63	87
2	28	72	100
3	25	46	71
4	19	35	54
5	12	30	42
6	5	71	76

To further check the accuracy of this method and the relative merits of the different procedures—the ASTM method and the ash-recovery method—analyses were made of laboratory-prepared synthetic oil mixtures. This may or may not give a check. As mentioned in the first part of this paper the form in which ash is present in oil is unknown and a synthetic oil may not have the properties of the natural oil which contribute to the formation of fly ash. A synthetic sample, then, could not prove low results; but it could indicate whether the results obtained by the new method were high.

Synthetic standard samples were made by mixing a mineral oil base with a metal naphthanate. The ash value of the oil was to be used as a blank. Four determinations of this value were made by the ash-recovery method and the results are shown in Table 6.

TABLE 6

Base Oil

Test No.	Ash Concentration (ppm)
1	52
2	54
3	55
4	59
Average	55

The results of the five runs are presented in Table 7. The amount of ash in the base oil was added to the amount of metal ash present in the form of the naphthanate and the total amount of ash recovered was compared with this value. In order to remove any question as to the actual amount of ash in the base oil employed as a blank, the value added to the calculated result was based on the ash value of 55 ppm. for the ash-recovery method and an ash value of 19 ppm. for the ASTM method. These figures were derived from the average of four ash determinations by each method.

As can be seen from an inspection of the data in Table 7 the average error of the ASTM method was much greater than that of the ash-recovery method; furthermore, the results of the ASTM method are consistently low, whereas the ash-recovery method exhibits a more random distribution of error. If it had been assumed that the ash-recovery method was correct and a value of 55 ppm. had been used in computing the ash in the blank for each method the results of the ASTM method would have been much farther from the correct values.

The metals used in these determinations, iron and nickel, were metals which did not appear to a great extent in the fly ash which had been examined spectrographically; therefore, the ASTM method and the ash-recovery method should both have been close to the correct value; and the ASTM method should have shown better results than in the case where calcium, silicon, or sodium was the metal under investigation. These checks, then gave the ASTM method the best possible chance to be correct.

TABLE 7

Comparison of Ash Recovery and A.S.T.M. Methods With Synthetic Samples

	ASH RECOVERY METHOD					A.S.T.M. METHOD				
Base oil (ppm)	55	55	55	55	55	19	19	19	19	19
Wt. of ash added as Iron naphthanate (ppm)	34	62	78	....	....	34	62	78	....	....
Wt. of ash added as Nickel naphthanate (ppm)	....	....	....	80	179	....	....	....	80	179
Total wt. of ash to be recovered (ppm)	89	117	133	135	234	53	81	97	99	198
Wt. of ash recovered (ppm)	80	110	137	140	263	34	58	91	65	201
Error	−9	−7	+4	+5	+29	−19	−23	−6	−34	+3
Percent	10.1	5.98	3.01	3.7	12.4	35.9	28.4	6.19	34.3	1.52
Average percent error	....	....	7.04	....	....	....	....	21.3	....	....

ACKNOWLEDGMENT

The authors express appreciation to Esso Standard Oil Company, Louisiana Division, for financial support of these studies.

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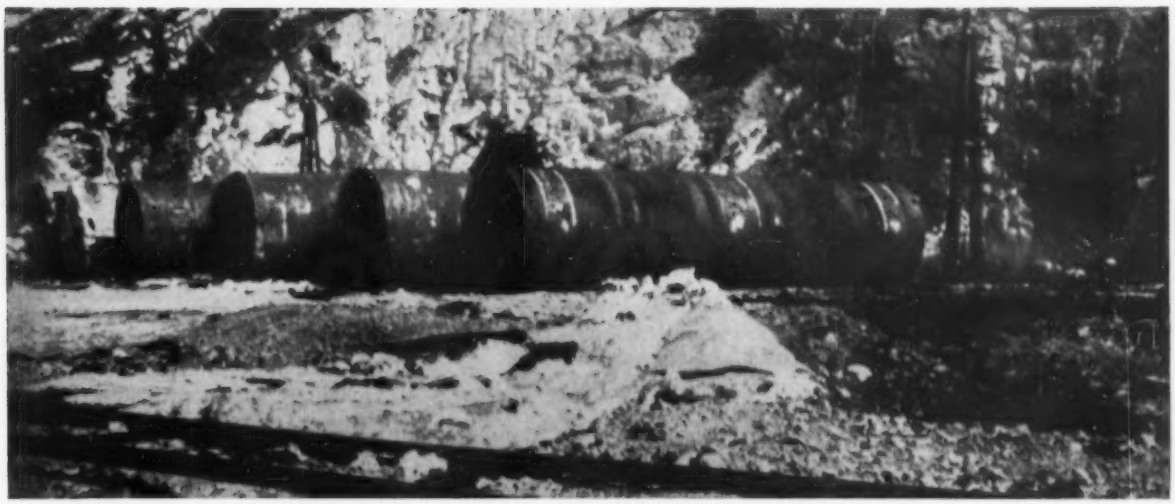

FIGURE 1—The crude storage is located just outside the entrance to the refinery.

This Refinery Went Underground

Some of the ideas used in this underground refinery could be considered in protecting our industry during time of war.

Herbert C. Fries
Empresa Petrolera Fiscal
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WHENEVER THERE is talk of wars, the vulnerability of the petroleum industry gets serious consideration. The civilian and defense economies of a nation may be greatly dependent on the security of this vital industry.

Here's the story of the only refinery that went underground to protect it against disastrous bombing. Although it is not new, some of the ideas incorporated in its construction may be considered in the protection of today's refineries.

This underground refinery was built by Germany in artificial caves at Ebensee, in the Alps of then occupied Austria. The entrances were protected by concrete blocks with about 60 foot of rock above them. The inner parts of the tunnels were protected by rock thicknesses of 800 to 1000 feet. The entrances to the refinery may be seen in Figure 1.

The underground system consisted of 12 parallel tunnels and 2 connecting tunnels with a total length of 2.8 miles. The cross-section of these tunnels was either 16.5 feet by 16.5 feet or 33 feet by 33 feet. The layout of the tunnels is shown in Figure 2.

A complete refinery of 7200 barrels per day capacity was planned for the tunnels. The processes were to include: crude topping, vacuum distillation, dewaxing, solvent extraction, acid treating and clay treating. Figure 3 is a flow diagram of the processes.

In addition to these processes, the tunnel was to protect storage tanks, steam generation, water treating, central electric supply, workshops, loading facilities, laboratory, and administration offices.

The total hourly energy consumption was estimated to be 87,000 pounds of steam and 3300 kilowatts of electricity. Water was to be supplied from a nearby lake at the rate of 400,000 gallons per hour. Fuel oil consumption was estimated to be 15,500 pounds per hour.

Sufficient ventilation was an important factor in this operation. Ventilators and exhaust fans were installed at the entrances to the tunnels. Two ventilation lines ran along the ceiling —one brought in fresh air and the other expelled waste air. Excess heat and explosive gases were drawn from the tunnel by this method. It was estimated that the entire plant would produce 2.8 million British thermal units per minute while in operation. Of this, about 1.5 million Btu's per minute would have to be removed by the ventilation system.

In addition to the usual fire protection equipment, a special steam line was placed in the tunnels. It had open flanges at various intervals along its length and could be operated from points outside gas tight doors. The gas tight doors separated the different rooms within the tunnels.

After completion of the tunnels, some sections were closed off by con-

This Refinery Went Underground . . .

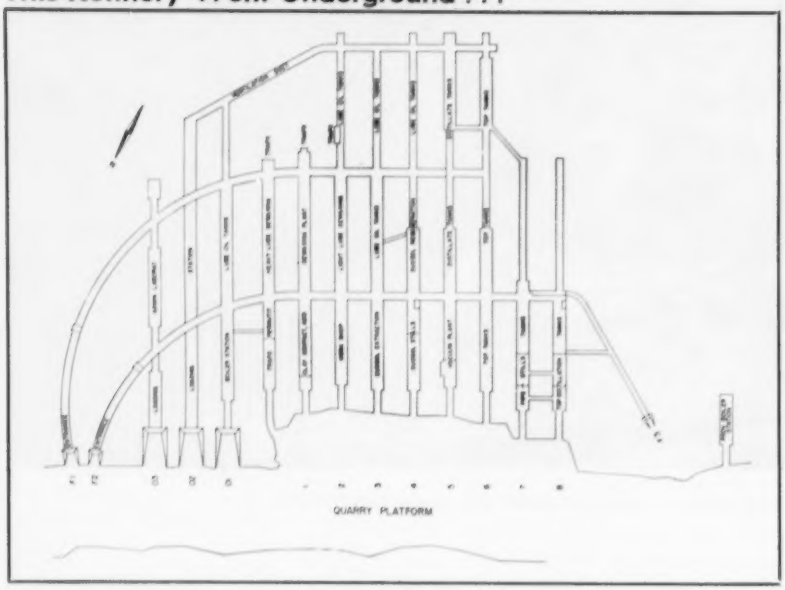

FIGURE 2—The network of tunnels contain the refining processes.

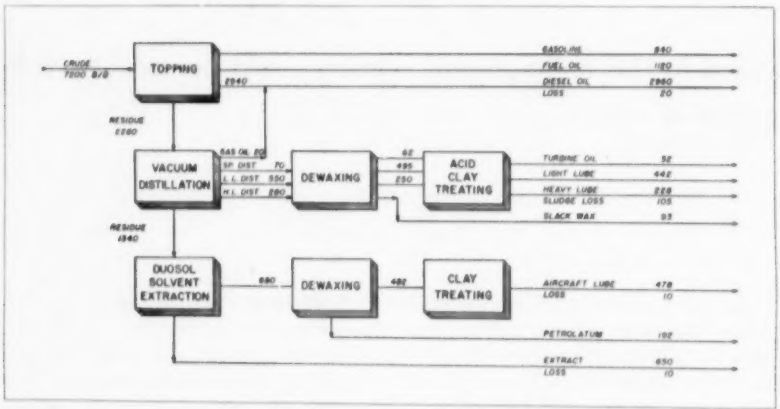

FIGURE 3—A complete refinery of 7200 barrels per day was planned for the tunnels.

crete walls to form natural reservoirs for crude oil storage. Many of the cylindrical tanks were moved in and mounted in horizontal positions. Then followed the installation of piping, transfer pumps, and electrical equipment.

The eight pipe stills of the topping unit were located in tunnel No. 7. Eight small bubble towers, along with product cooling, feed preheating, and associated exchangers and pumps were located in the adjoining tunnel No. 8. The units were arranged in a style that is similar to the modern packaged plants.

The combustion gases of all furnaces passed through a common stack extending upward through 57 feet of rock. Where the stack meets the ground level, a concrete block was placed to insure protection of this vital system.

The topping unit was placed into operation about three months before the end of the second world war. It produced motor gasoline, diesel oil, and residue.

In tunnel No. 5, an additional excavation was necessary in a vertical direction for 82 feet. This was required to make room for the vacuum distillation column which was to be 79 feet high. This unit was not finished by VE-Day, but would have been completed about two months later.

The ventilation system proved to be adequate for personnel comfort. With all of the stills in operation, the room housing the topping plant had a temperature of 77 to 86 F. between the floor and a height of six feet. A complete air change was obtained about nine times each hour.

At the end of the war, this refinery was the only one in U. S.-controlled territory of Austria. Great importance was given to the plant at this time because other industries and normal daily life depended much on the fuels which were produced there. The plant underwent several modifications so that it could produce solvent naphtha, kerosine, lubeoils and asphalt from naphthenic crude.

After consumption of the stored crude oil, the plant was to be shut down. Though never totally completed, it served a good purpose during the difficult postwar times. It was one of the first factories which was started up after the end of the war because it had not suffered the fate of the other conventional refineries.

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Meet the Author

HERBERT C. FRIES, a native of Austria, is general superintendent of refining for Empresa Petrolera Fiscal at Lima, Peru. He was graduated from Vienna's Technical University in 1939 with an engineering degree in technical chemistry. He was onetime a chemist in corrosion, development and operations at Oilrefinery "Nova" in Vienna. After World War II, he was in charge of the U. S.-controlled Oilrefinery Ebensee. This plant, a subterranean refinery, is in the Austrian Alps. With Empresa Petrolera Fiscal, he constructed a portable gasoline plant on Peru's north coast and recently completed a refinery on the Amazon River.

An easy way to . . .

Determine Heat Transfer Coefficients

Several correlation methods are brought together in this article to permit the determination of heat transfer coefficients from a chart and a minimum of computation. The method is shown to be accurate enough for liquid hydrocarbons in normal design situations.

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HERE IS A method to estimate the film coefficients of heat transfer to liquid hydrocarbons flowing through tubes. The method is particularly useful when information on thermal conductivity and specific heat is lacking. In these cases, a correlating factor covering the over-all effect of thermal conductivity and specific heat of liquid hydrocarbons is established. This factor may then be introduced into standard methods normally used when complete knowledge of the physical properties is available.

A number of excellent correlations of film coefficients of heat transfer of flowing fluids are available. The correlation of Sieder and Tate[5] is typical and probably the most widely used.

This correlation is based on three dimensionless ratios:

$$\text{Reynolds' Number} = \frac{DG}{\mu}$$

$$\text{Length to Diameter Ratio} = L/D$$

$$\text{Modified Colburn } j = \frac{hD}{k}\left(\frac{C_p\mu}{k}\right)^{-1/3}\left(\frac{\mu}{\mu_w}\right)^{-0.14}$$

The first two are independent of specific heat and thermal conductivity being concerned with flow rate, viscosity and physical layout of the exchanger. The j factor can be written in the alternate form (dimensional) given below.

$$j = \frac{h\mu}{GC_p^{1/3}k^{2/3}}\left(\frac{\mu}{\mu_w}\right)^{-0.14}$$

From this it is evident that j can be evaluated if the factor $C_p^{1/3}\,k^{2/3}$ is known. Conversely once j is evaluated from a Sieder and Tate chart, the film coefficient becomes

$$h = j\,(C_p^{1/3}k^{2/3})\left(\frac{G}{\mu}\right)\left(\frac{\mu}{\mu_w}\right)^{0.14}$$

A correlation factor may be obtained when it is noticed that the product of $k^{2/3}\,C_p^{1/3}$, at any one specific gravity, is relatively independent of temperature. To establish this relation, values are used for the specific heats and thermal conductivities of liquid hydrocarbon products at various temperatures as reported by Cragoe.[2] Average values for the product of $k^{2/3}\,C_p^{1/3}$ are reported by Clarke.[1] These values can be represented within acceptable design accuracy by either of the following equations:

$$k^{2/3}\,C_p^{1/3} = \frac{0.124}{S^{0.8}} \qquad (1A)$$

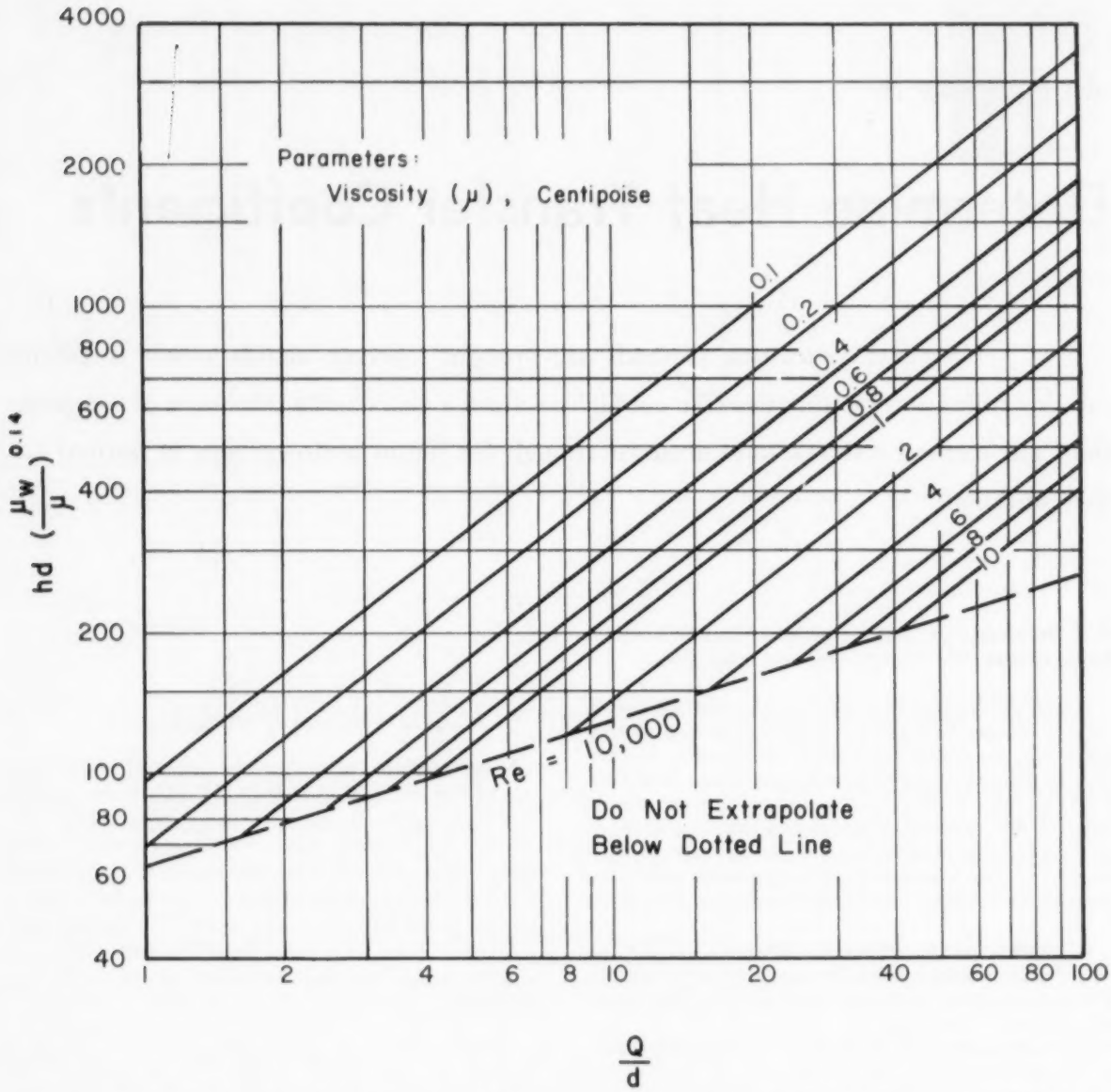
$$k^{2/3}\,C_p^{1/3} = \frac{0.12}{S} \qquad (1B)$$

Equation (1A) is more convenient for calculations when flow is in the turbulent zone and (1B) is more convenient for streamline flow as will be shown.

Now a simplification may be applied to the equation of Sieder and Tate[5] for turbulent flow; i.e., Reynold's number greater than 10,000. The original equation may be written in the form

$$h = \frac{0.027\,k^{2/3}\,C_p^{1/3}\,G^{0.8}}{D^{0.2}\,\mu_a^{0.466}}\left(\frac{\mu}{\mu_w}\right)^{0.14} \qquad (2)$$

Substitution of equation (1A) in equation (2) for $k^{2/3}\,C_p^{1/3}$ and substitution of the flow rate in a tube in



Use this chart to estimate the film coefficient of heat transfer to hydrocarbon liquids inside tubes. It is easier to use because . . . you do not need thermal conductivity and specific heat data for the liquids.

gpm, Q, for the mass velocity results in the following simplified dimensional equation:

$$h = \frac{31.2}{d\,\mu^{0.466}} \left(\frac{Q}{d}\right)^{0.8} \left(\frac{\mu}{\mu_w}\right)^{0.14} \qquad (3)$$

It should be noted that equations (2) and (3) are valid only for flow inside circular tubes with Reynold's number over 10,000 and are not valid for flow in annuli.

The equation of Sieder and Tate[5] for streamline flow, Reynold's number less than 2100, can be written in dimensional form

$$h = \frac{24.2\,k^{2/3}\,C_p^{1/3}}{d} \left(\frac{W}{L}\right)^{1/3} \left(\frac{\mu}{\mu_w}\right)^{0.14} \qquad (4)$$

Substitution of equation (1B) into (4) gives

$$h = \frac{2.9}{Sd} \left(\frac{W}{L}\right)^{1/3} \left(\frac{\mu}{\mu_w}\right)^{0.14} \qquad (5)$$

Equation (5) is recommended for calculation of co-

efficients for streamline flow. Again it must be noted that equations (4) and (5) apply only to flow in circular tubes and for Reynold's number below 2100.

The flow range of Reynold's numbers between 2100 and 10,000, sometimes called the transition range, is not adequately covered by available equations. Estimation of film coefficients for this range can be made by the use of the Sieder and Tate, or other available charts and equation (1A).

A chart method is proposed here for turbulent flow. The chart is prepared by writing equation (3) in the form

$$hd\left(\frac{\mu_w}{\mu}\right)^{0.14} = \frac{31.2}{\mu^{0.466}}\left(\frac{Q}{d}\right)^{0.8} \qquad (6)$$

which leads to straight lines on a log-log plot with μ as a parameter.

The figure permits direct reading of coefficients. It does not require a separate calculation of the Reynold's number since the terminal line represents Reynold's numbers of 10,000 which is the limit of validity.

A comparison of several design methods is given in Table 1. This is a comparison of film coefficients calculated by Figure 24 of Kern,[3] TEMA[6] and the chart presented here—or equation (5) if the flow is streamline. These methods were chosen for comparison since they are readily available and probably the most widely used. Data for thermal conductivity and specific heat were obtained from Maxwell.[4]

Comparison of the coefficients calculated by the three methods shows that the simplified equations presented here are in very close agreement with commonly used methods or design calculations. Maxwell's values for thermal conductivity are given as independent of specific gravity while Cragoe[2] indicates some variation with specific gravity at any one temperature. The use of the data of Maxwell will give slightly less conservative coefficients of heat transfer due to his slightly higher values of k. This small difference in coefficient is generally negligible and will have only a small effect on the over-all coefficient.

The effect on heat exchanger design will be most pronounced when the tube side coefficient is appreciably smaller than the shell side and therefore becomes governing. Even in this case, the difference is well within the limits of accuracy for normal design and either source of thermal conductivity data is satisfactory.

TABLE 1
Heat Transfer Film Coefficients
(For ¾" 14 BWG Tube)

S	Temp. (°F)	μ (c.p.)	Q (gpm)	L/D	Re	Coefficients (h) (a)	(b)	(c)
0.934	150	0.6	3	...	25200	275	288	259
0.934	400	1.0	5	...	25100	319	331	300
0.8251	300	4.0	10	...	11100	275	264	272
1.0	250	8.0	18	...	12200	324	326	324
0.8762	550	1.0	3	...	14100	202	203	203
0.934	300	0.3	4	...	67000	465	465	437
0.934	150	50	7.94	247	800	40.5	42.6	36
0.934	400	100	5	123	250	41.6	46.5	38.7
0.934	300	300	3	123	50	35	...	32.5
0.8251	300	30	4.04	165	600	37.4	39.8	35.6
1.0	250	75	4.17	82	300	42.4	51	40
0.8762	550	10	3.17	330	1500	27.8	29	25

(a) Figure 24 Kern. (b) Page 99 TEMA Standards. (c) Figure 1 or equation 5.

NOMENCLATURE

C_p — Specific heat, Btu/lb.-°F.
D — Inside diameter, ft.
d — Inside diameter, in.
G — Mass velocity, lbs./hr.-ft.$_2$
h — Film coefficient of heat transfer, Btu/hr.-ft.$_2$-°F., based on inside area.
k — Thermal conductivity, Btu/hr.-ft.-°F.
L — Length of tube, ft.
Q — Flow rate, gpm.
Re — Reynolds Number, dimensionless.
S — Specific gravity, 60 F./60 F.
μ — Viscosity, c.p. @ bulk temp.
μ_a — Viscosity, lb./ft. hr.
μ_w — Viscosity, c.p. @ film temp.
W — Flow rate, lbs./hr.

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Meet the Authors

RICHARD E. WINSTON handles design of all chemical and petrochemical process equipment for Day & Zimmermann, Philadelphia, with emphasis on heat-transfer. Before joining the company in 1952, he was with W. H. & L. D. Betz four years as a research engineer engaged in water-treatment studies. Winston is a chemical-engineering graduate of the University of Louisville (1947) and holds a M.S. degree from the University of Pennsylvania (1948). He is registered as a professional engineer in Pennsylvania.

Winston

Clarke

LOYAL CLARKE has been with Air Products, Inc., Allentown, Pa., for the past year, designing low-temperature units for the separation of oxygen, hydrogen and other gases. Before joining the company, he was engaged in engineering design work with Day & Zimmermann, Inc., seven years. His background also includes services with the Bureau of Mines, Petroleum Chemicals, Inc., and Celanese Corporation. A graduate of Oregon State College, he has done graduate work at the University of California and at California Institute of Technology.

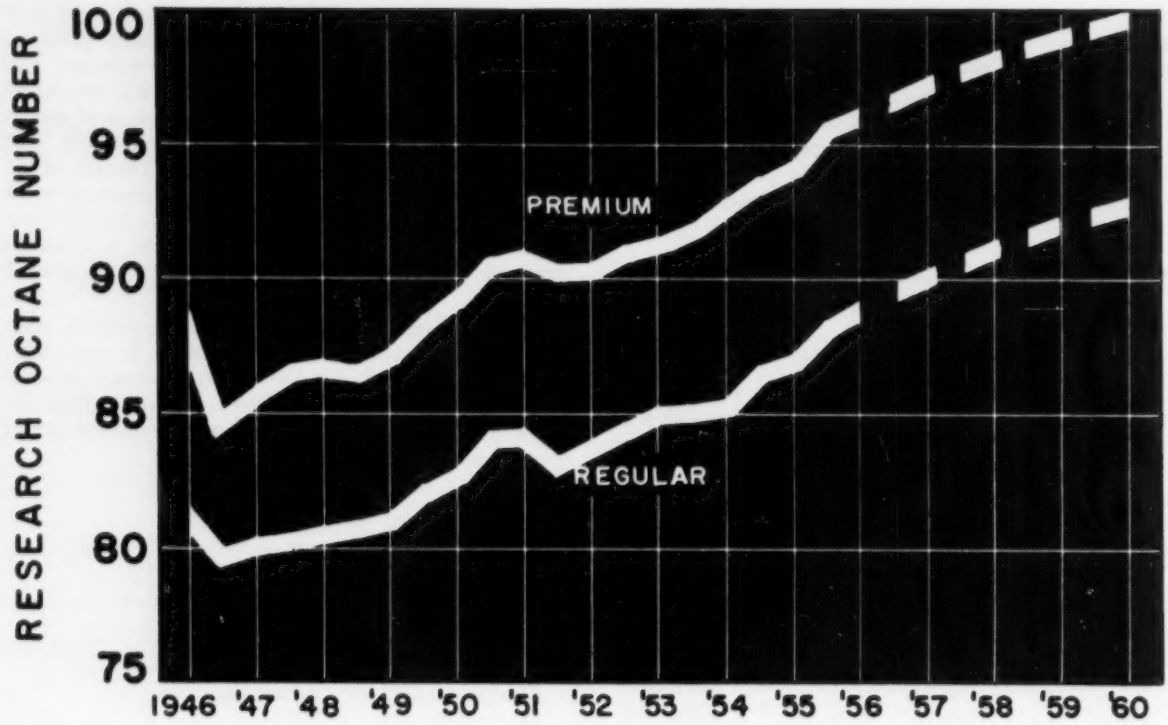

FIGURE 1—Average octane trend for U. S.: Rate of increase will taper off to one octane per year.

What Will Gasoline Be Like in 1960?

U. S. gasolines probably will have average octane ratings of 93 for regular and 100 for premium. Front-end volatility will be lighter and tail-end heavier.

J. G. Moxey, Jr.
Sun Oil Company, Philadelphia, Penn.

ENGINE DEVELOPMENT has always gone hand in hand with advances in fuel quality, and this all-important relationship is certainly going to continue. The improvements in engine performance and economy forecast for 1960 will be possible only if there is a corresponding increase in the octane quality of commercial gasolines. Competition in the automotive industry forces compression ratios up to levels which enable the public to sort out the fuels that knock from those that do not. Competition in the petroleum industry at the same time forces octane ratings up to levels that will handle these compression ratios. Neither of these trends would be possible without the other.

Figure 1 shows the postwar trend in octane quality, together with a forecast out to 1960. Octane numbers have been increasing for the last 25 years at a rate of about one octane per year. Over the past few years, as the industry has been modernizing its refineries and building catalytic reformers, the rate has actually been closer to two octanes per year. This very rapid rate of increase will probably taper back off to about the one octane per year level, and the average premiums are shown at 100 by 1960

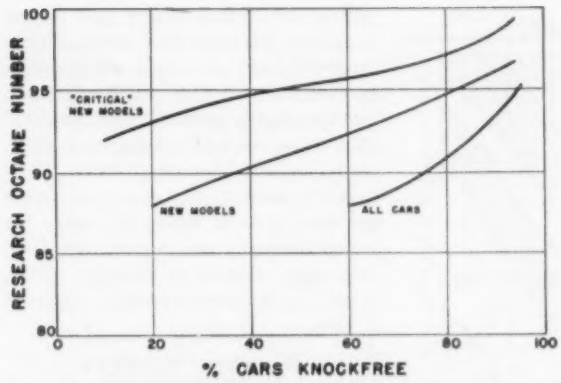

FIGURE 2—Car octane requirements for mid-1956: Critical group includes 25 percent of this year's production.

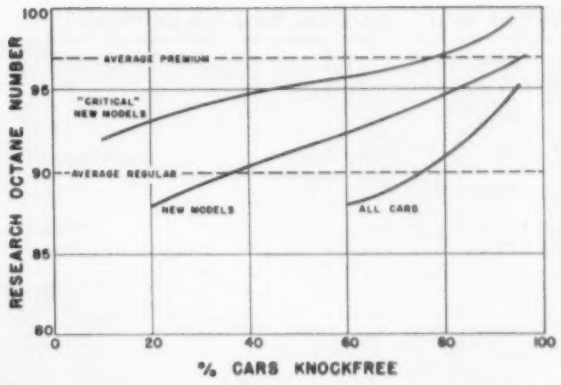

FIGURE 3—Car octane requirements for mid-1956: An argument for more than two grades.

with the regular grades at about 93. Different areas will be up and down from the nationwide average, of course, as in the past.

These increases should be adequate to permit compression ratios to go up to the 10:1 level. The degree of knock satisfaction provided will be just about the same as it now is.

A spread of seven octane numbers is shown between the 1960 regular and premium grade gasolines. This is about the same as it has been over the last ten years. A number of people[1-4] have suggested that the two grades will eventually come together, and the industry will have to discard its present two-fuel system in favor of a single gasoline. There are two reasons that are given.

Holaday[4] suggested several years ago that there might be a ceiling in octane quality at about the 98 to 100 level. His thought was that the premium grade gasolines can be brought up to this level using practical and known processes. It would be difficult, however, to carry them up higher because of the very large volume that is required. The same processes could also be used to bring all the gasoline a refinery makes up to this same level. The conclusion that is drawn, of course, is that a single fuel at this level will result.

The author does not believe that this is what's going to happen. It would seem more logical to expect the petroleum industry to be sufficiently ingenious to develop practical processes for carrying octane numbers well up above 100 and to develop ways of making these fuels available to cars that have been designed to take full advantage of them. There may be a ceiling on octane numbers, but it probably will not be at the 100 level.

Raviolo[1] has suggested another line of reasoning in support of the single-fuel theory. His thought is that the octane requirements of all cars will eventually reach the same level, and there will be no need for anything but a single fuel. Again, the author does not believe that this is what's going to happen—at least not within the next five to ten years.

Figure 2 shows an estimate of car octane requirements as they probably will be this year. The "All Car" curve shows the distribution of octane requirements for the entire car population. The "New Model" curve is for the cars that will be produced this year, and the "Critical" curve is for the high requirement group that is aimed specifically at premium grade fuels. This group, incidentally, will include about 25 percent of this year's production.

The single-requirement theory proposes that all new cars will eventually be aimed at premium grade fuels. This would bring the upper two curves together, and the new cars at least would require only a single grade of fuel. It seems to the author that before the petroleum industry would want to convert over to this single fuel, the lower curve would also have to move up to this level, and all three curves would have to flatten out considerably.

If the new cars that are produced each year continue to go up in compression ratio and octane requirement, the older cars will continue to spread out over a considerable range below this level. And so long as this situation exists, there doesn't seem to be much justification for the industry to convert to a single grade.

Actually, there are some strong arguments in favor of going in the opposite direction. Figure 3 shows the 1956 average premium and regular grades superimposed on the curves of Figure 2. All of those cars with requirements below the 90 level will operate knock-free on the average regular grade. Those above this level have no choice but to jump up to the premium if they don't want their cars to knock.

And those cars with requirements above 97 have no choice but to tolerate the knock or resort to some mechanical adjustment to eliminate it. This is an oversimplification, of course, since individual fuels in different areas will vary from these averages; but it will serve to illustrate the point.

There would be a great many advantages to some system that would make available to the public a series of octane levels that would completely cover the knock requirements of all the cars on the road—in somewhat smaller increments than the seven octane spread that now exists between premium and regular grades. An individual car owner could then seek out the fuel that his engine needed. He would be able to provide himself with knock-free operation, and he would have to pay only for the quality he needed.

A system like this is now being tried experimentally by Sun Oil Company in a limited marketing area. An automatic blending pump is used to dispense a series of fuels of increasing octane quality, with the top quality fuel being high enough to cover the requirement of any car now on

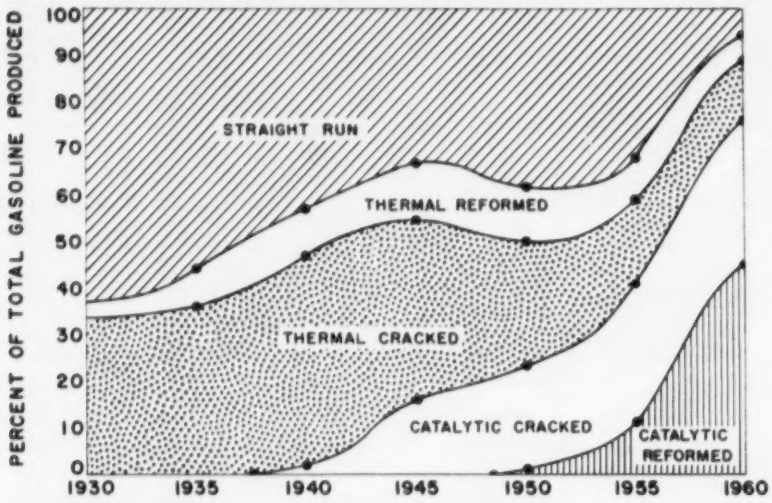

FIGURE 4—Processing trends: Catalytic reforming will take a 45 percent bite in 1960.

the road. This is an experiment to see whether the public would like to buy its gasoline in this way, and whether it can understand such a system and learn to use it properly.

If it is successful, it would seem to offer many advantages. It would open up the possibility of providing fuels of very high octane quality for a small proportion of the total cars on the road that had been designed to take full advantage of them. The owner of an older car would not suffer, since he would be able to buy a fuel that was appropriate for his car. He would not have to pay for the more costly octane numbers that his engine was not capable of utilizing properly.

Refinery Processing—The steady increase in gasoline octane quality has been accomplished by a steady improvement in refinery processing. The changes that have taken place are illustrated in Figure 4.[5] Prior to World War II, motor gasolines were made primarily from straight run, thermal reformed, and thermal cracked material. Catalytic cracking was introduced in 1937 and has grown rapidly in the postwar period. This growth has largely taken place at the expense of the older thermal version of cracking. Today, 35 percent of the country's gasoline is made by catalytic cracking.

It is expected that catalytic reforming will expand even more rapidly than did catalytic cracking. Since about 1950, ten new processes for catalytic reforming have been introduced, and the plants that have been built already have a charge capacity of more than one million barrels per day. Catalytic reforming at present makes 10 percent of our gasoline, but this figure is expected to surge to almost 45 percent by 1960. Straight run will virtually disappear from motor gasoline. Although not shown on the chart, alkylation will almost certainly be used to a greater extent as octane numbers go higher.

The changes in processing that have been increasing octane quality have also been increasing sensitivity; the spread between Research and Motor method ratings has been getting larger.[5,6] Catalytic reforming and such processes as Iso-Plus and Rexforming produce highly aromatic gasolines, and their use will tend to increase sensitivity beyond its present level. If alkylate is used to any extent in motor gasoline, it will tend, of course, to restrict this increase in sensitivity. The following table is an estimate of the trend in aromatic content and sensitivity.

AROMATIC CONTENT AND SENSITIVITY

Year	% Aromatics	Sensitivity*
1950	13	6.5
1955	19	7.0
1960	38	10.0

*Research minus Motor

So far, the indications are that the milder high compression engines will utilize the more sensitive fuels quite satisfactorily, at least so far as antiknock performance is concerned. Whether other problems will appear as a result of the higher aromatic content will have to be explored.

Volatility—Turning now to the subject of volatility, there are a number of changes that have been taking place.[7] Figure 5 shows the postwar trend in Reid vapor pressure. Front-end volatility has been increasing steadily. This appears to be a result of the economic pressure in the petroleum industry to use as much of the available butanes as possible, since there is no indication that the newer automobiles as a group are any less

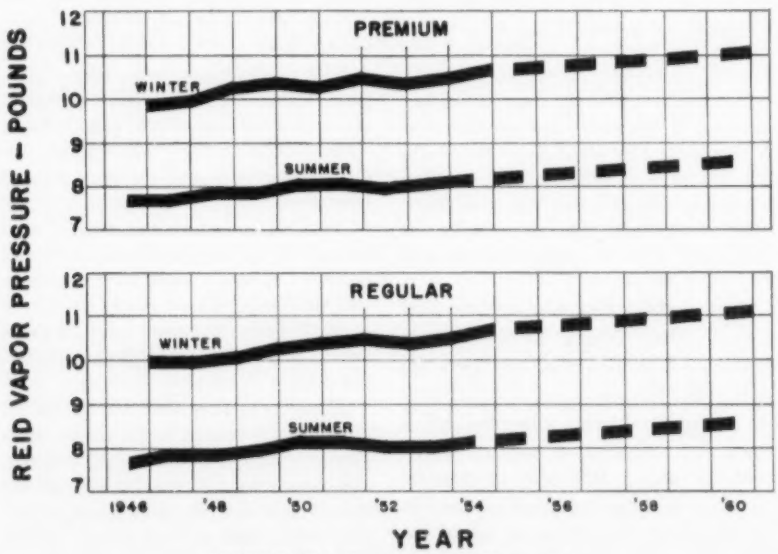

FIGURE 5—Volatility trends: Steadily upward.

prone to get into hot fuel handling troubles than older models.

Over the last 4 or 5 years, there has been a great deal of work done exploring the ability of vehicle fuel systems to handle more volatile fuels and studying the amount of trouble actually occurring in service.[8-11] Apparently the result of this work has been to prompt the industry to increase front-end volatility of both summer and winter grade gasolines.

The upward trend in vapor pressures is shown as continuing on out to 1960. It would be logical to expect that the experience gained by those companies who have marketed higher volatility fuels will prompt others to follow their lead.

Ten percent points have shown a decline, in line with the higher vapor pressures—Figure 6. Fifty percent points have also been dropping slightly, Figure 7, but a leveling out of this trend will probably occur as the increasing use of catalytic reformers begins to be felt. The two most important performance factors that are dependent upon the mid-boiling range are acceleration and warm-up and carburetor icing. There doesn't appear to be any reason to expect any great change in the need for controlling mid-volatility for good acceleration and warm-up. Carburetor icing, on the other hand, will probably be taken care of mechanically in the newer engines and the need for controlling this problem by means of volatility may gradually be eliminated.[12]

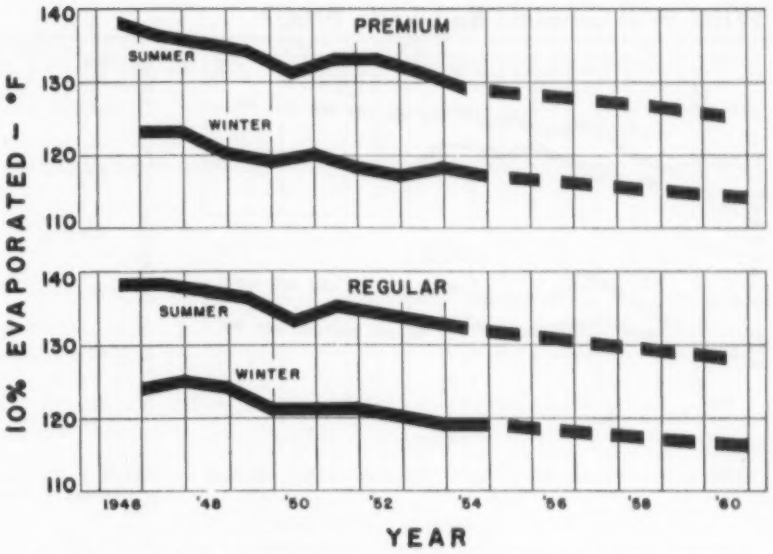

FIGURE 6—Trends in 10 percent point: A decline in line with higher vapor pressures.

Tail-end volatility has been gradually getting heavier. Figure 8 shows the trend in 90 percent points. There are, actually, two conflicting trends that are apparent in this portion of the distillation curve, but the net result will probably be somewhat higher 90 percent points by 1960. Some companies have chosen to reduce tail-end boiling points, apparently feeling that they obtain some performance benefits. Opposed to this is the increasing availability of high-octane, high-boiling components from catalytic cracking and catalytic reforming.

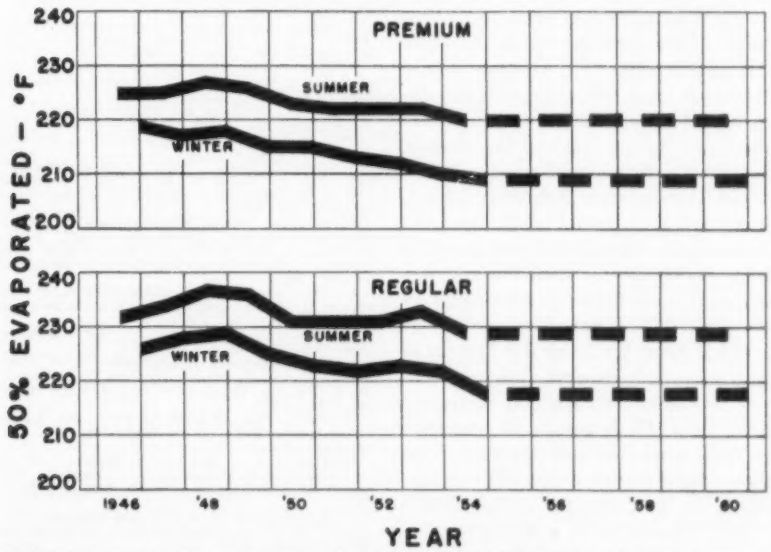

FIGURE 7—Trends in 50 percent point: Use of catalytic reforming will level out the downward trend.

Figure 9 shows the change in octane quality that occurs as the 90 percent point is increased with typical refinery stocks. With the demand for ever-increasing octane numbers, there's going to be steady pressure to take full advantage of the quality that is available from the aromatics in the higher boiling fractions of the catalytically processed stocks.

Additives—Additives have been a necessary part of gasoline manufacture for a good many years; and over the last three or four years, of course, there has been a great deal of activity in this area.[8-16] How much of this recent activity has been aimed at providing actual performance benefits, and how much has been aimed at providing subject matter for advertising is a little difficult to judge; but in all fairness, there probably has been some of both.

The following table lists the various classes of additives that are in current use:

GASOLINE ADDITIVES

Tetraethyllead	Anti-corrosion Agents
Lead Scavengers	Anti-icing Agents
Dyes	Top Cylinder Lubricatns
Anti-gum Agents	Detergents

Tetraethyllead has been used for so long that it is hardly thought of as an additive any more. Along with the tetraethyllead, various combinations of ethylene dichloride and ethylene dibromide have been used as a means of scavenging the lead and minimizing the detrimental effects of its combustion products. More recently, a number of companies have been us-

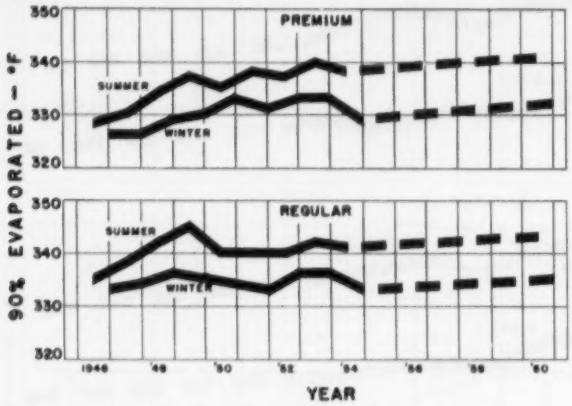

FIGURE 8—Trends in 90 percent point: Tail-end volatility has been getting heavier.

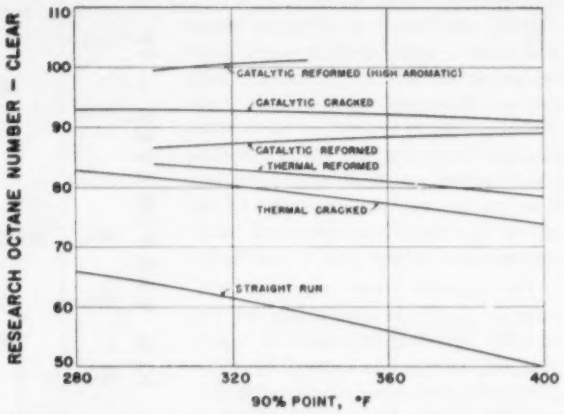

FIGURE 9—Octane versus volatility: Demand for high octanes will pressure use of aromatics in the higher boiling fractions of catalytically-processed stocks.

ing various compounds of phosphorous and boron as depoist "modifiers" in addition to the conventional scavengers.

Dyes, of course, are used universally and must be included in all gasoline containing tetraethyllead. Nearly all gasolines contain some sort of antioxidant and/or metal deactivator for protection against instability in storage and deposit formation in engine fuel or intake systems. There is an increasing use of anti-corrosion agents. Their primary purpose is to prevent rusting and corrosion in refinery equipment, storage tanks, and pipe lines. But they probably provide protection for automobile fuel systems as well, at least insofar as it is needed.

Isopropyl alcohol and a variety of other materials are being used during the appropriate seasons as a means of minimizing carburetor icing and/or fuel system freeze-ups. Top cylinder lubricants are also being used in some gasolines. A few have been treated with so-called "detergents" for protection against carburetor deposits.

Almost without exception, modern-day gosolines contain some combination of these additives. As time goes on, it seems logical to expect that development work on additives will continue. And this work is certain to produce some new and improved formulations.

Future Engines—The engines will almost exclusively be improved versions of the present V-8 high compression engine. By 1960, average horsepower may go from the present 205 to about 245; compression ratios, similarly, from 8.4 to 10:1. Fuel economy, hopefully, will be improved by nearly 10 percent.

Fuel injection in one form or another will almost certainly be tried, but whether it will achieve any large-scale acceptance is not clear at this time. The gas turbine may appear experimentally some time between 1960 and 1965, but its future is by no means agreed to as yet. Both of these developments will be watched quite closely by the petroleum industry, however, because of their possible impact on fuel requirements.

Original presentation was before the NGAA annual meeting, Fort Worth, Texas, April 13, 1956.

Meet the Author

JOHN G. MOXEY, JR., joined Sun Oil Company in 1935, following his graduation from Swarthmore College with a bachelor's degree in mechanical engineering. He started in the Research and Development department, of which he is now assistant director. Before taking his present assignment, he served Sun as manager of its Automotive Research laboratory. He is a member of the API Automotive Research committee, has been active in the Coordinating Research Council and is chairman of the CFR-MFD Volatility group. He also has been active in the Society of Automotive Engineers, having been vice president for fuels and lubricants since 1952. He is author of a number of articles on fuel and lubricants and their adaptation to automotive equipment. In addition to his bachelor's degree, Moxey holds a degree as mechanical engineer from Swarthmore College.

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Lube Oil Additives—A Big Business!

Approximately $150 million worth of chemicals will be consumed in 1956.

R. S. Aries and A. P. Sachs
R. S. Aries and Associates, New York City

EVERYONE IN the petroleum field knows that chemical additives are used in lube oils. The dosage used, however, is so low that most people feel that there is an insignificant amount of chemicals used for this purpose. It is true that the additive content is quite low, but the extremely large volume of lubricating oil produced makes the total chemical usage a high value. For example, almost 600 million pounds of additives will be used for lube oil alone in 1956. This includes 290 million pounds of detergents and about 150 million pounds of V.I. improvers. Other values are given in the tables. A good discussion on the use and purpose of these additives was included in an eight-part series[1] on the subject and will not be repeated here.

U. S. LUBRICATING OIL PRODUCTION ESTIMATE for Passenger Cars (Million Gallons)

	Multigraded Oil	Premium Oil	Regular Oil	Total
1955	125	310	110	555
1956	150	310	110	570
1960	220	290	100	600

	Diesel Oils
1955	23
1956	24
1960	28

LUBE OIL GROWTH PATTERN (Million Gallons)

	Automotive	Highway Motor Oil	Passenger Cars Only
1955	1075	800	555
1956	1090	810	570
1960	1150	850	600

DETERGENT CONTENT OF VARIOUS LUBE OIL TYPES (%)

Regular	0.5
Premium Lube	4.0
Multigrade Lube	5.0
Heavy Duty (Truck & Tractor)	4.0
RR Diesel	4.0
Automatic Transmission	4.0

TYPES OF DETERGENTS (Million Pounds)

	Sulfonates	Phenates	Others	Total
1955	135	130	10	275
1956	145	132	13	290
1960	160	135	35	330

V. I. IMPROVERS (Million Pounds)

	Multi-grade Oils	Extreme Pressure Lubricants	Automatic Trans-mission	Total
1955	75	45	3	123
1956	95	50	3	148
1960	140	37	4	181

TYPES OF V. I. IMPROVERS (Million Pounds)

	Polymethacrylates	Others
1955	66	54
1956	77	61
1960	95	75

ANTIOXIDANTS (Million Pounds)

	Multi-grade	Premium	Regular	Heavy Duty	Total
1955	12	26	7	25	70
1956	13	26	6	28	73
1960	19	22	6	31	78

TOTAL CONSUMPTION OF LUBE OIL ADDITIVES (Million Pounds)

	1955	1956	1960
Detergents	275	290	330
V. I. Improvers	123	148	181
Antioxidants	70	73	78
Pour Point Depressants	29	29	30
Oiliness Agents & EPLA	57	59	65
Total	564	599	684

ESTIMATED CONSUMPTION OF ADDITIVES FOR 1955

ADDITIVE	Dosage	Million Pounds	Million Dollars
Detergents	2–10%	275	62
Antioxidants & Corrosion Inhibitors	0.4– 2%	70	20
V. I. Improvers	0.5–10%	123	25
Pour Point Depressants	0.1– 1%	29	11
Extreme Pressure Agents	5–10%	50	14
Defoamants	0.0002–0.07%	....	....
Anti-rust Agents	0.1– 1%	....	....
Oiliness Agents	0.1– 1%	7	3
Fluorescent Dyes	.....	....	....
Total	.....	....	135

LITERATURE CITED

[1] Kalichevsky, V. A., "Lube Oil Additives," Petroleum Refiner, 1949, June, p. 97; July, p. 170; August, p. 121; September, p. 85.

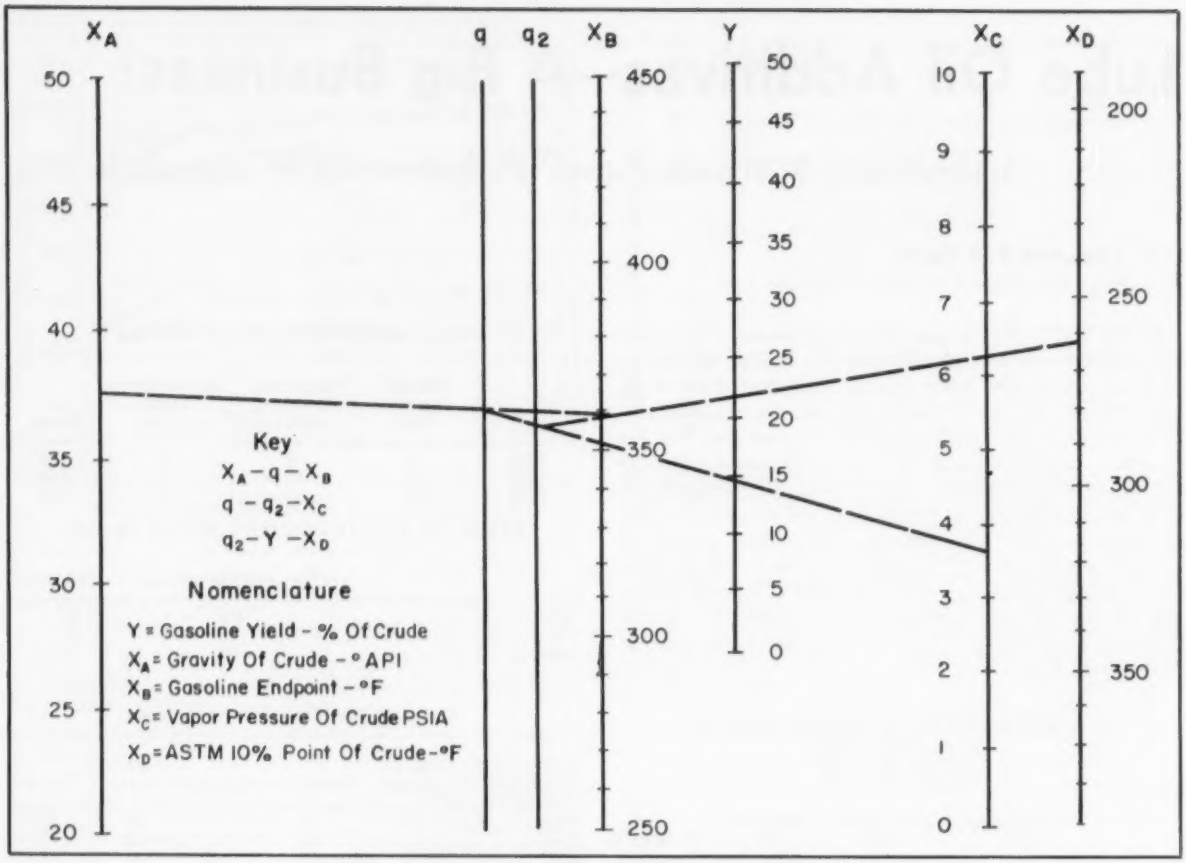

FIGURE 1—Nomograph—Gasoline yields from crude oil properties.

Estimate Gasoline Yields From Crudes

Save time by using this method to calculate gasoline yields. It gives yields for any end point and requires only gravity, vapor pressure and 10% point.

Nilon H. Prater
The Chemstrand Corporation, Decatur, Alabama

NO LONGER MUST you wait for laboratory crude evaluations to estimate gasoline yields. Using this method the yield of any end point gasoline can be calculated from routine crude test data.

The old problem of scheduling and planning refinery operations can be simplified by the use of this rapid and reliable estimation method. While certain assumptions must be made there is a definite need for such a method.

Scheduling and planning refinery process operation plays an important role in the refining industry. One phase of this is the production of straight run gasoline from crude oil distillation and its subsequent processing to finished gasolines. Gasoline yields are usually estimated or obtained from laboratory crude evaluations. The percent yield for a given gasoline end point is not controllable by the pipe still operator. Assuming constant fractionating efficiency the yield is a function of the crude charged to the distillation tower. To insure optimum scheduling of tankage and rerun facilities a reliable yet simple method for estimating gasoline

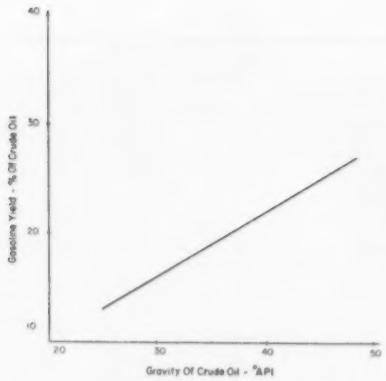

FIGURE 2—Effect of crude gravity on gasoline yields.

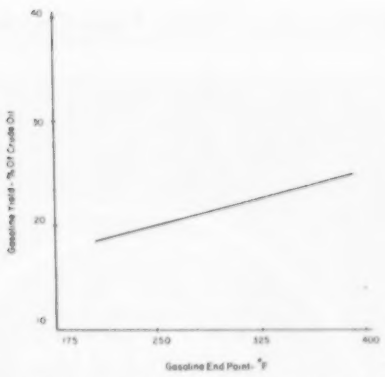

FIGURE 3—Effect of gasoline end point on yield.

yields of any end point was needed.

Such a method was developed by relating crude oil properties and gasoline end point with yields from crude oils. The following variables were used:

- Gravity of crude oil.
- Gasoline end point.
- Vapor pressure of crude oil.
- ASTM 10 percent distillation point of the crude oil.

The importance of these variables in determining gasoline yields can be visualized from Figures 2, 3, 4 and 5.

Meet the Author

NILON H. PRATER is a process engineer with Chemstrand Corporation in Decatur, Ala. Before joining that company, he was with Magnolia Petroleum Company, assigned to the Technical department at its Beaumont, Texas, refinery. He joined Magnolia, following his graduation from Georgia Institute of Technology in 1951 with a degree in chemical engineering. At Beaumont, his experience primarily was in distillation and light ends.

The relationship was developed from Hempel evaluations of crude oils as observed in the laboratory. The distillation efficiency resulted in no gap or overlap between the ASTM gasoline end point and the ASTM initial boiling point of the kerosene fraction. The data used in developing the correlation are shown in Table 1. For verification of its value in scheduling process operations the yield data from crude oil distillation units were compared with calculated yields using this method. The relationship can be expressed as follows:

$$\text{Equation 1. } Y = 0.314\,X_A + 0.148\,X_B + 0.862\,X_C - 0.086\,X_D - 24.872$$

Where: Y = gasoline yield, percent of crude oil

X_A = crude oil gravity, API

X_B = gasoline end point, F

X_C = crude oil vapor pressure, PSIA

X_D = ASTM 10 percent distillation point of crude oil, F

Practical application of this relationship is simplified by using the accompanying nomograph shown in Figure 1.

A linear relationship was assumed among all variables. Simple correlation coefficients were calculated between all the variables—thus observed yields were correlated with each of the variables in equation 1, and these in turn correlated with each other. Using the nomenclature that the simple correlation coefficient between variables 1 and 2 is r_{12}, then:

$$r_{12} = \frac{N\Sigma(1 \times 2) - (\Sigma 1 + \Sigma 2)}{\sqrt{[N\Sigma(1)^2 - (\Sigma 1)^2]\,[N\Sigma(2)^2 - (\Sigma 2)^2]}}$$

Where N is the number of observations.

This correlation coefficient is a measure of the fit of a straight line to the data. If $r = \pm 1$ the fit is perfect. If it is zero, there is no linear relationship. This value should vary between $+1$ and -1. The simple correlation coefficient between yield and the variables in Equation 1 is as follows:

$$r(YX_A) = 0.60227$$
$$r(YX_B) = 0.54394$$
$$r(YX_C) = 0.63066$$
$$r(YX_D) = -0.61247$$

TABLE 1

Crude Oil Properties and Actual Gasoline Yields

Crude Oil Gravity, °API	Crude Oil, Vapor Pressure, PSIA	Crude Oil, ASTM 10 Percent Point, °F.	Gasoline End Point, °F.	Gasoline Yield Percent of Crude Oil
38.4	6.1	220	235	6.9
40.3	4.8	231	307	14.4
40.0	6.1	217	212	7.4
31.8	0.2	316	365	8.5
40.8	3.5	210	218	8.0
41.3	1.8	267	235	2.8
38.1	1.2	274	285	5.0
50.8	8.6	190	205	12.2
32.2	5.2	236	267	10.0
38.4	6.1	220	300	15.2
40.3	4.8	231	367	26.8
32.2	2.4	284	351	14.0
31.8	0.2	316	379	14.7
41.3	1.8	267	275	6.4
38.1	1.2	274	365	17.6
50.8	8.6	190	275	22.3
32.2	5.2	236	360	24.8
38.4	6.1	220	365	26.0
40.3	4.8	231	395	34.9
40.0	6.1	217	272	18.2
32.2	2.4	284	424	23.2
31.8	0.2	316	428	18.9
40.8	3.5	210	273	13.1
41.3	1.8	267	358	16.1
38.1	1.2	274	444	32.1
50.8	8.6	190	345	34.7
32.2	5.2	236	402	31.7
38.4	6.1	220	410	33.6
40.0	6.1	217	340	30.4
40.8	3.5	210	347	26.6
41.3	1.8	267	416	27.8
50.8	8.6	190	407	45.7

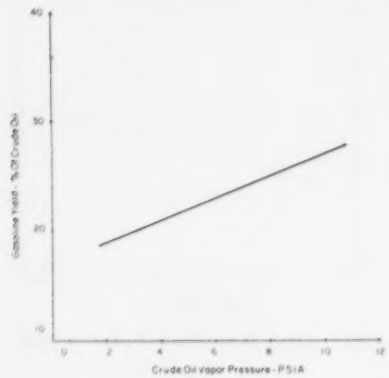

FIGURE 4—Effect of crude vapor pressure on gasoline yields.

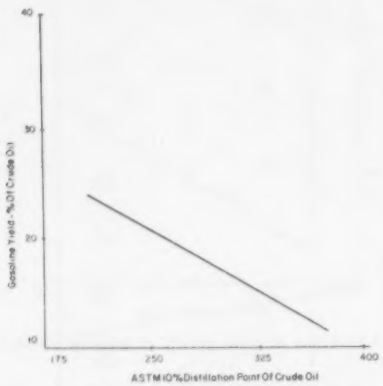

FIGURE 5—Effect of ASTM 10 percent distillation point of crude on gasoline yields.

The ASTM 30 percent distillation point of the crude oil was also correlated with gasoline yield. The interfactor correlation coefficient between the ASTM 10 and 30 percent points was 0.93222. Since this value is very close to 1 either variable could be used. If both variables are used only one will contribute any appreciable value to the equation.

In place of a line, as discussed in the simple correlation case, one can think, geometrically, of a plane which is determined by the five variables in Equation 1 where yield is the dependent variable and the remaining four are independent. Such a correlation describing the fit of the plane to the data is called a multiple correlation coefficient. This value, r^2, for the variables was 0.94. The closer this value approaches 1, the better is the relationship that exists between the variables. Thus, Equation 1 is a general equation of a family of planes relating the part each independent variable plays in the final estimate of the yield.

The interpretation of a correlation coefficient, either qualitatively as a measure of the strength of relationship of two variables or quantitatively in terms of r^2 as giving the percentage of the variance of the dependent variable as accounted for by the relationship, is a purely mathematical interpretation and is completely devoid of any cause or effect implications. The fact that two variables tend to increase or decrease together does not imply that one has any direct or indirect effect on the other. Both of them may be influenced by other variables in such a manner as to give rise to a strong mathematical relationship. In this case $\sqrt{0.94}$ or 97 percent of the variance of yield has been accounted for by the independent variables. The remaining part of the standard error of estimate is due to factors other than those accounted for in Equation 1.

The accuracy of these data have been estimated statistically and found to be within the limits of experimental error. The standard error of estimate, which is the standard deviation of the error of estimating the yield by use of Equation 1, is 2.35 percent. Actual yields and yields estimated by Equation 1 are compared in Table 2.

The application of these data is illustrated by the following example:

What yield of gasoline having an end point of 358 F. can be expected from a crude oil having the following properties?

Gravity—37.4 API
Reid Vapor Pressure—3.7 PSIA
ASTM 10 percent distillation point—261 F

These values are substituted in Equation 1 and solved for yield.

$$\text{Yield} = (0.314 \times 37.4) + (0.148 \times 358) + (0.862 \times 3.7) - (0.086 \times 261) - (24.872) = 21$$

Therefore a yield of 21 percent of crude oil can be expected. These values assume constant fractionating efficiency. A correction factor may be applied for each pipe still if tower efficiencies vary appreciably.

This empirical method requires only data from routine tests on the crude oil while developing the gasoline yields in the laboratory requires considerable time and laboratory technique. In addition, the 4 point distillation method for evaluation crude oils is laborious and requires careful attention throughout the distillations.[1] These methods can be controlled to determine the gasoline yield within about one percent but for scheduling and planning refinery process operations, the additional time to determine yields by these methods is not justified.

ACKNOWLEDGMENT

The author is grateful to The Chemstrand Corporation for permission to publish this article and to V. A. Kalichevsky for his helpful suggestions and criticisms. Also, thanks is given to C. Erickson and L. J. McGovern for their assistance in developing this data.

LITERATURE CITED

[1] Slater, E. O., *Oil Bulletin* 17, 272-4 (1931).

TABLE 2

Percentage Gasoline Yields—ACTUAL VS. CALCULATED

Actual Yield	Calculated Yield	Difference
6.9	8.3	+1.4
14.4	11.0	−3.4
7.4	5.7	−1.7
8.5	12.1	+3.6
8.0	5.2	−2.8
2.8	1.5	−1.3
5.0	6.7	+1.7
12.2	12.5	+0.3
10.0	8.9	−1.1
15.2	17.9	+2.7
26.8	26.4	−2.4
14.0	14.8	+0.8
14.7	14.2	−0.5
6.4	7.4	+1.0
17.6	18.6	+1.0
22.3	22.6	+0.3
24.8	22.7	−2.1
26.0	27.5	+1.5
34.9	30.5	−4.4
18.2	14.5	−3.7
23.2	25.6	+2.4
18.0	21.5	+3.5
13.1	13.3	+0.2
16.1	20.0	+3.9
32.1	30.3	−1.8
34.7	33.2	−1.5
31.7	28.9	−2.8
33.6	34.2	+0.6
30.4	24.6	−3.8
26.6	24.3	−2.3
27.8	28.3	+0.5
45.7	42.4	−3.3

● This photograph shows the welding of Revere 70-30 Cupro-Nickel to make a digester to handle both organic and inorganic acids. The metal was chosen because of its superior corrosion-resistance. It is also widely used for condenser tubes and plates, heat exchangers, evaporators, stills and similar equipment where its enduring qualities are required to meet corrosive fluids such as salt water and many chemicals.

The digester shown was made by the Nooter Corporation, 1430 S. Second St., St. Louis 4, Mo., which is an important supplier to the chemical, refinery, utility and similar industries. Weight of the vessel, 9,000 pounds; length, nine feet, inside diameter, 66 inches. Revere collaborates closely with Nooter from time to time on welding matters. If you have a welding problem on non-ferrous metals, see the nearest Revere Sales Office.

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Looking for a Treasure?

AN ENCYCLOPEDIA is one of the books reviewed this month. This book, *An Encyclopedia of the Chemical Process Industries,* treats the practical aspects of raw materials, processes, equipment and finished products of the industry in encyclopedic form. It should prove a treasure of information to those engaged in chemical processing, whether in handling research, production, control, purchasing or sales.

Keep Going to Page 242.

"Night Evaporation?"

A SIMPLE WAY of locking plugs on tanks which have to be located outside the plant yard is explained in "How-to-Do-It." Another suggestion from this department is one on how to stop fluctuation in liquid-liquid extraction towers.

Keep Going to Page 244.

Last of the Write-Offs

OFFICE of Defense Mobilization has granted Phillips Petroleum Company permits for fast amortization on $49.1 million worth of defense-needed petroleum-refining and alkylation facilities. For details of this and other companies receiving the last certificates before the government closed its write-off program, see "Who's Building."

Keep Going to Page 249.

New Developments

IT LOOKS like the use of isomers will be one of the next big developments in petroleum refining. And Universal Oil Products Company has come up with a new process for upgrading pentane and hexane fractions. That's taken up in "What's Happening in Industry."

Keep Going to Page 298.

What's Coming Up

A NUMBER of important meetings still are to be held before summer comes. Be sure to check through "Meetings Calendar," to see what is coming up in the societies and associations of most interest to you and your department.

Keep Going to Page 311.

How to Find Out

DO YOU know W. H. Vaughan? You should. He is Tide Water Associated Oil Company's gas-utilization boss in Houston and now holder of the Hanlon Award. The award, presented at NGAA's Dallas meeting, is the highest honor in the natural-gasoline industry and one of the ranking awards of the petroleum industry. To find out something about Jack Vaughan and how he came to receive this honor, see "What's Happening Among Men in the Industry."

Keep Going to Page 312.

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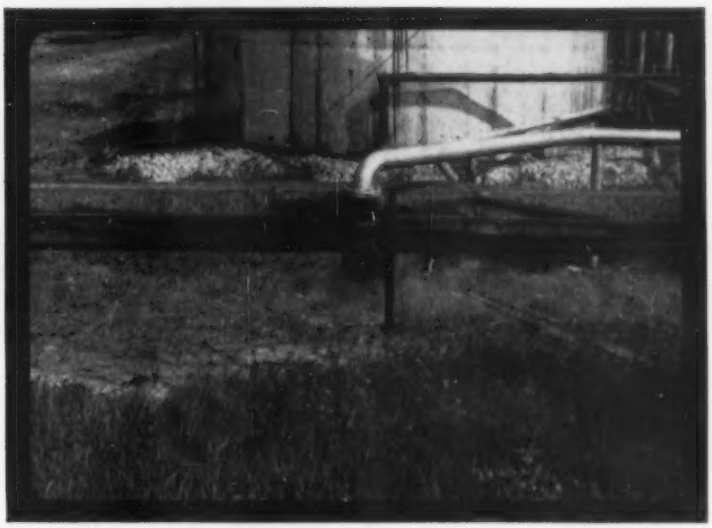

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SERVING INDUSTRY THROUGH PRACTICAL APPLIED SCIENCE

Reviewing New Books . . .

Scheduling of Petroleum Refinery Operations, by Alan S. Manne. This book reviews conventional refinery cost-accounting methods, and then presents four case studies.

They cover the allocation of individual crude oils to several refineries, at different locations; naphtha reforming; gasoline blending, and scheduling for a small integrated plant which performs cracking, recycling and blending. For this full-scale refinery problem, not only a running plan is considered, but also a case involving the construction of new capacity.

As a result of the individual calculations, it is possible to understand how a refiner might respond to changes in several kinds of variables—the market prices of refined products, quality specifications of these products and the amount of capital available for investment in new equipment. With patience and some laboratory work, it is practical to analyse the manufacturing process activities within any required degree of detail.

(Harvard University Press, Cambridge 38, Mass., 185 pages, $5. For sale by Gulf Publishing Company, P. O. Box 2608, Houston.)

Professional Engineering Registration Laws, edited and published by Alfred L. McCawley. This book is a synopsis of engineering registration laws in the 48 states, plus the District of Columbia, Alaska, Hawaii and Puerto Rico. It makes a comparative analysis of 34 critical legal points concerning registration. The final chapter is a commentary on pertinent Supreme Court opinions.

(Alfred L. McCawley, Trustee Publication Fund, Jefferson City, Mo., 614 pages, $8.75.)

Legal Problems in Engineering, by Melvin Nord. Written by an engineer who also is a practicing attorney, this book is designed for use and reference by engineers. It does not pretend to make the engineer independent of the lawyer, but it will help him to avoid legal problems before they arise and to work more effectively with lawyers if they do.

The book deals with almost any legal subject that has any bearing on engineering. This breadth is possible because of a number of space-saving features such as the elimination of detailed documentary examples which are available elsewhere.

Savings in space also has been possible because the book does not attempt to combine law and economics. Wherever economic topics affect the law or engineering, they are fully developed. But the author has not tried to make his book do the work of two.

A special feature of this book is its treatment of case material. Instead of following the casebook approach, it uses cases to illustrate discussions and point out legal problems. They are presented in a condensed form which eliminates unneeded side issues. There is a minimum of legal jargon and the treatment is particularly valuable to the non-lawyer seeking a survey of the field.

(John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 391 pages, $7.50.)

An Encyclopedia of the Chemical Process Industries, by J. B. Stewart. This book treats the practical aspects of raw materials, processes, equipment and finished products of the chemical-process industries in an encyclopedic form. It also lists definitions of technical and scientific terms which are frequently encountered in these industries.

It should prove a treasure of information—collected for the first time in one volume—to those who are actively engaged in chemical processing, whether in the handling of research, production, control, purchasing or sales. As it lists the manufacturers and uses of thousands of trade-marked products, it should also serve as a buyers' guide to chemists and consumers.

This encyclopedia will be equally helpful to beginners and students who plan to enter the field of chemical processing.

(Chemical Publishing Company, 212 Fifth Avenue, New York 10. 820 pages, $12.)

ASTM Standard, 1955, prepared by the American Society for Testing Materials. This is the society's largest triennial book of ASTM Standards. The edition has more than 11,000 pages and includes more than 2150 standard specifications, tests and definitions for materials. It is issued in seven parts, each pertaining to a particular area or group of areas of materials.

Fuels, Petroleum, Aromatic Hydrocarbons and Engine Antifreezes is the part of most interest to members of the petroleum-refining industry. This part contains 242 standards, 117 of which are new or have been revised since 1952. These groups of subjects are covered:

- Coal—Classification, sampling, tests, screen analysis, size, dustiness, etc.
- Petroleum—Fuel oils, gasoline, diesel fuels, Stoddard Solvent; tests.
- Coke.
- Antifreezes.
- Gaseous Fuels.
- General Testing Methods.
- Aromatic Hydrocarbons—Benzene, naphtha, toluene, xylene; tests.

(American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Part 5, 1496 pages, $11.)

A Positive Displacement Pump for Accurate Metering of Liquids, by Lawrence R. Crisp and Frank O. Anderson. Design and construction of a new type positive displacement pump for metering liquids is discussed in this report prepared by the National Institute of Health.

Two syringes operated in a reciprocal manner were used in the construction. Each syringe has a fixed stroke of 1.0 inch with the capacity a direct ratio to the input speed. A variety of synchronous motors and a variable speed drive were used to obtain selective output and input speeds.

Illustrated with photographs of the pump and its components, the report also describes in detail its construction, uses, and limitations.

(Office of Technical Services, Commerce Department, Washington 25, D. C., 11 pages, 50 cents.)

Chemical Processing and Equipment, prepared by the Atomic Energy Commission. This volume helps advance solutions to the chemical-processing system problem of costs in handling special materials, and the laboratory problems of the time consumed in remotely or semiremotely conducted experiments.

The treatment is in two parts, the first dealing with the chemical processing of irradiated fuel elements, the second, with the handling of irradiated materials in laboratory operations.

The material on chemical processing consists of a description of the process and engineering-design features of a plant system designed to reclaim highly-enriched uranium from irradiated fuel elements made of an aluminum alloy or enriched uranium and aluminum. It includes flow sheets, plant arrangement drawings and illustrations of key equipment items.

The second section is a catalog of equipment and tools which have been developed or adapted for handling laboratory quantities of highly radioactive materials. Approximately 250 items are described, ranging from complicated remote-viewing systems to simple manipulative devices.

(McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., 302 pages, $6.)

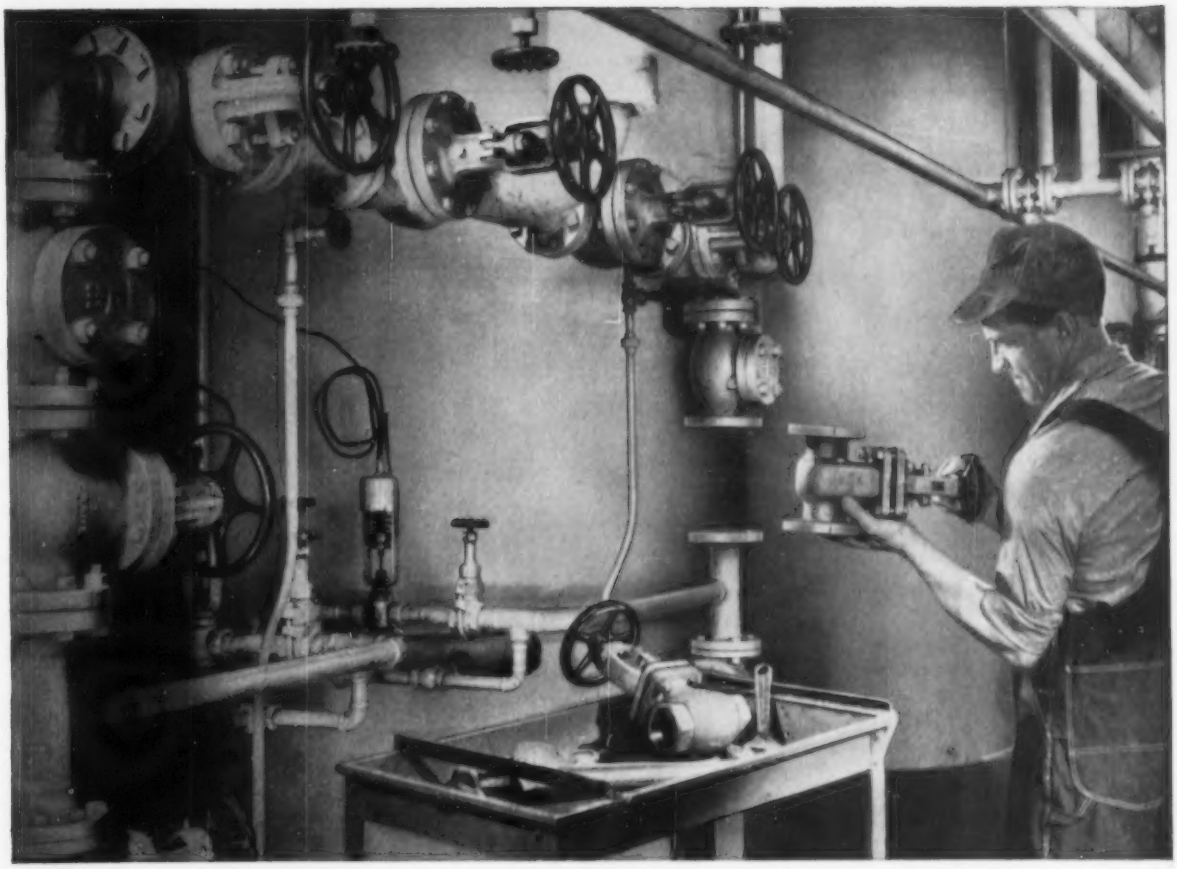
Hydogen Effusion Methods for the Determination of Corrosion Rates in Aqueous Systems at Elevated Temperature and Pressure, by M. C. Bloom and M. Krulfeld. A hydrogen-effusion method, described as a novel technique for measuring the corrosion of metals at elevated temperatures and pressures in aqueous heat-exchange systems, is the subject of this recent report of research at the Naval Research Laboratory.

This report contains an analysis of the limitations of prior techniques of corrosion rate measurement to determine the kinds of materials best suited to resist attack by aqueous media at elevated temperatures and pressure. The new system is based on the fact that, in a closed system at elevated temperature, the hydrogen which results from the corrosion reaction will diffuse through the walls of the metal at a comparatively rapid rate. This hydrogen is collected and measured in a vacuum system of known volume which surrounds the system under test, and the rate of hydrogen evolution thus measured gives a direct measure of the rate of corrosion of the metal.

(Office of Technical Service, Commerce Department, Washington 25, 18 pages, 50 cents.)

Tentative Standard Procedure for the Measurement of Natural Gas with Orifice Meters. Generally, all of the data in this revision is the same as included in the original bulletins, except that it has been expanded to cover a still wider range of conditions. The Table of Standard Hourly Coefficients in this bulletin were taken directly from A.G.A. Gas Measurement Committee Report No. 3. These tables were computed by electronic calculators and it is feld that the possibility of human error in their preparation has largely been eliminated. Data in this C.N.G.A. bulletin are given to five significant figures in most cases. Table of contents appears on the reverse side of this circular.

(California Natural Gasoline Association, 510 West Sixth Street, Los Angeles 14, $6.)



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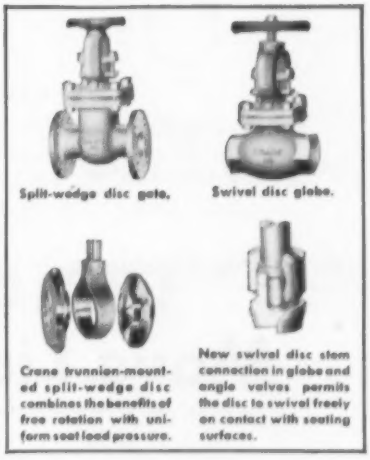
Globe and angle valves now feature a modified plug-type disc that combines the advantages of the easier seating of the narrow ball-to-flat seat and the high resistance of the wider plug-type disc to corrosion, erosion and cutting. In addition, these valves offer a new swivel disc-stem connection that seats the disc squarely every time. Minimum clearance eliminates vibration.

These valves are available in 18-8 SMo and Craneloy 20 . . . in gate, globe, angle and check patterns . . . ½" to 6" . . . screwed or flanged ends. Rated 150 p.s.i. at 500° F.—230 p.s.i. at 100° F. *For more detailed information*, confer with your CRANE representative or write to the address below for the 12-page circular AD-2080.



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New swivel disc stem connection in globe and angle valves permits the disc to swivel freely on contact with seating surfaces.

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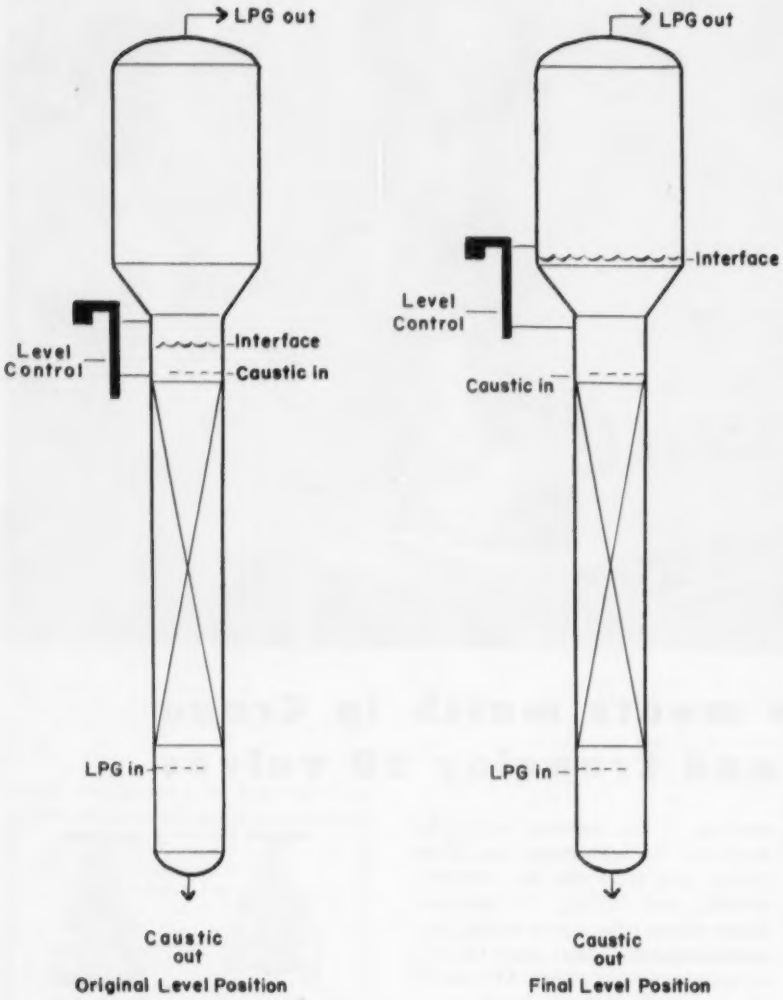
How To Do It . . .

$10 is paid for each accepted idea. Mail to Editor, Petroleum REFINER, P. O. Box 2608, Houston 1, Texas.



How to Stop Fluctuation?

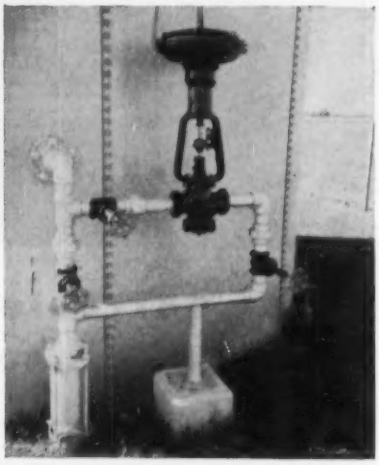
Move Liquid Level

Liquid-liquid extraction towers usually operate at low pressures. But a recent application to remove H_2S from LPG necessitated operation above 300 psig.

The process required metered flow of the aqueous absorbent solution, back flow of the LPG overhead and maintenance of liquid level at the phase interface. The conventional instrumentation is shown at the left in the figure above.

After this operation was started, it was found that the liquid level control became so sensitive that minor changes in the LPG stream caused the bottom flow to fluctuate widely, thus increasing entrainment of one phase in the other.

It was not possible to desensitize the level control by adjustment. Elevation of the level control to a position above the transition section of the tower, however, permitted a larger surge for the same change in level and effectively dampened out fluctuation and entrainment. This installation is shown at the right in the figure.

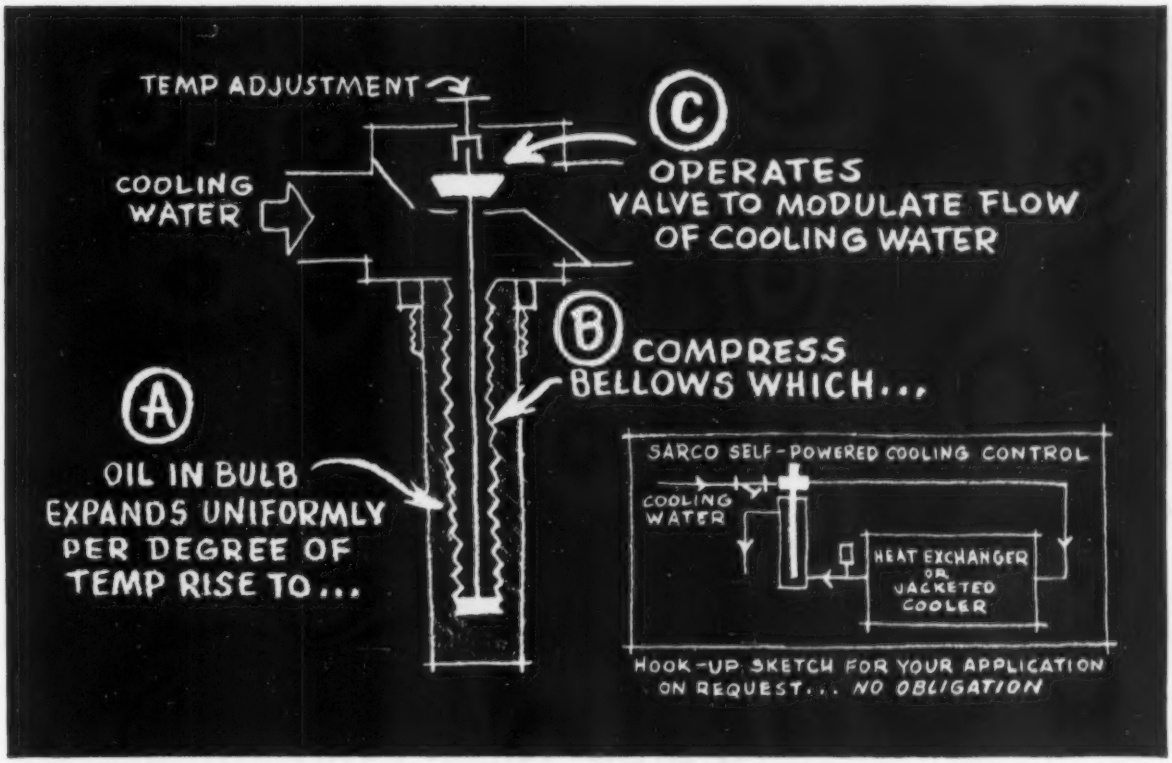


Regulate Water Level By Remote Control

A simple way of controlling the water level in a storage tank may be made by setting a motor valve on the inlet from the water supply line. This is done by using the air-control system, setting a control on the tank float and running a copper tubing to the valve shown.

When the water in the tank is sufficiently high, pressure is turned into the top of the diaphragm of the motor valve and this shuts off the flow to the tank. When the level falls a few feet, the pressure is released from the diaphragm and water is turned back into the tank.

The valve is set around the main block valve into the tank above a


TEMP ADJUSTMENT
C
OPERATES VALVE TO MODULATE FLOW OF COOLING WATER
COOLING WATER
B
COMPRESS BELLOWS WHICH...
A
OIL IN BULB EXPANDS UNIFORMLY PER DEGREE OF TEMP RISE TO...
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Simple, trouble-free design—as you can see above, a temperature control need not be complicated! Self-powered...no electricity or compressed air required. Self-contained...no exposed mechanism. Packless...no packing to wear or leak.

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The low price makes it possible for you to use Sarco AUTOMATIC temperature controls for ALL control jobs, not just the big ones! For example, the ¾" size costs only about $39! Mail the coupon now.

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sleeve and a swaged nipple so the entire assembly can be boxed and insulated against freezing in the winter. By building the box against the tank and flush with the tops of the valve stems, the valve wheels can be operated and the valve can be easily reached for servicing.

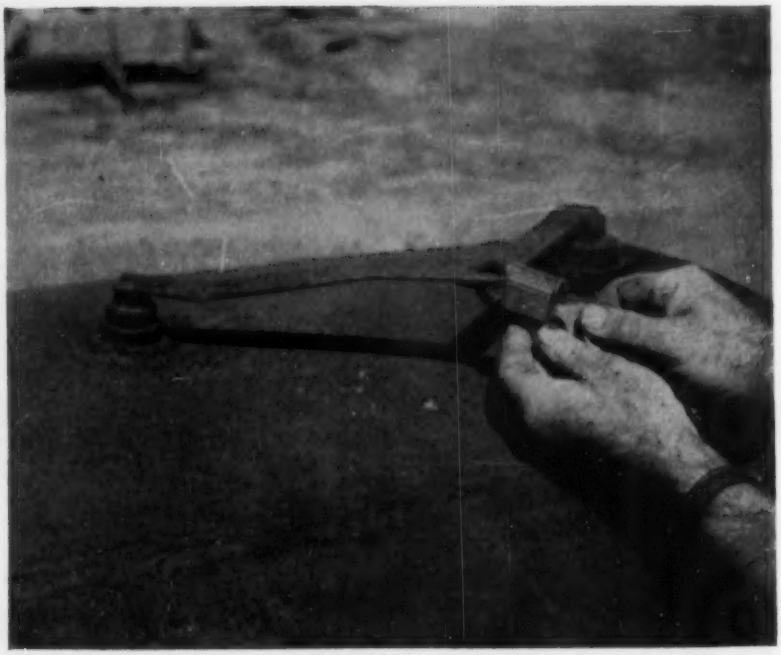
Since there are no packing glands above the main valve, the diaphragm can be left out in the weather for ready inspection and servicing.

Rack Knack Allows Quick Bit Picking

Here's a bit rack which will be a decoration for the tool shop and at the same time provide a quick means of selecting bits. It can be made from three old stove legs and an assortment of circular plates attached to piston rods.

To make this rack, drill holes around the circumference of the plates, making them slightly larger than the shank of the bits they are to hold. Then stamp the front of the plate with the bit size.

Set the plates down on an offset in the piston rods. This way, they can be swung around to the front for a quick selection of bits.

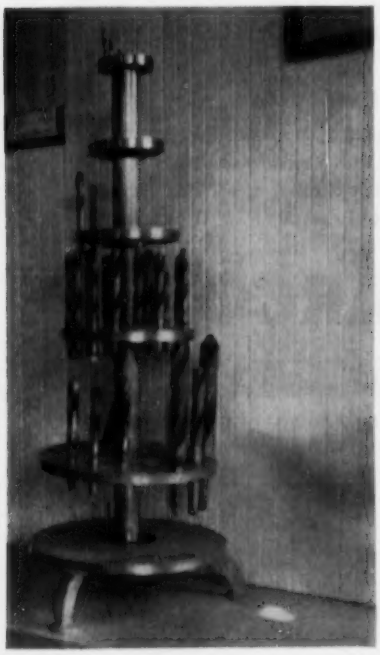


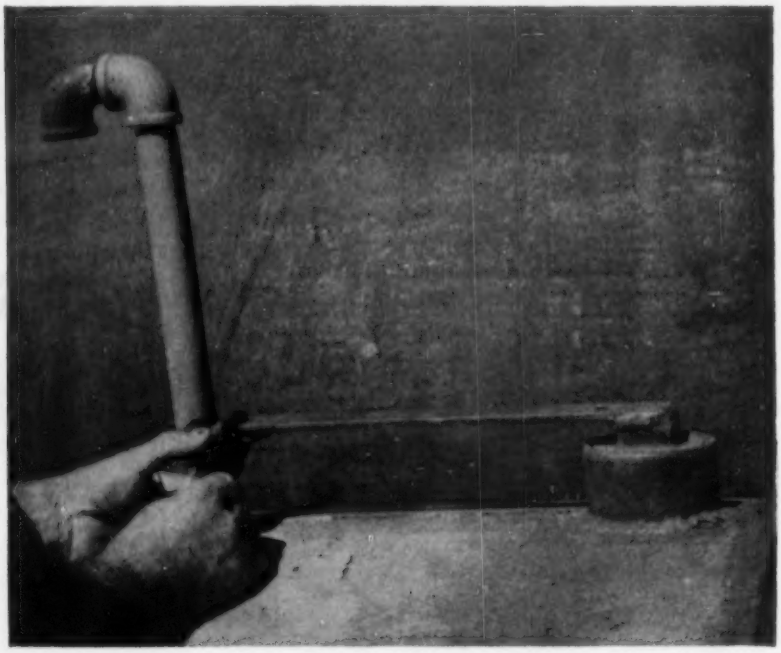
Use Locks on Tank Plugs To Stop 'Night Evaporation'

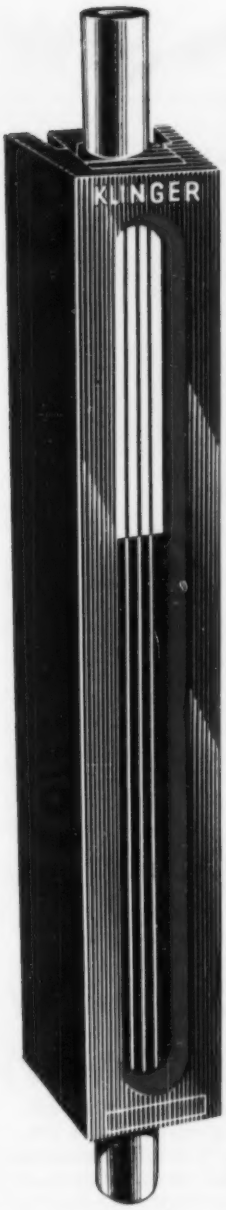
Here is a simple way of locking plugs on tanks which have to be located outside the plant yard. This way, the levers used to lock the plugs also serve as wrenches to open them.

First, screw the plugs on tight and mark them so the levers can be made the right length for matching holes to fit the locks. After taking the levers a distance from the tanks, braze them fast and burn holes to make a place for the locks.

One view shows two plugs being locked simultaneously, and the other shows a plug being locked to the brether pipe which is fixed so it can not be unscrewed without removing the lock.







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Single row of tightening bolts

Body free from distortion

Glass easily removed

Gage body turnable, free to expand, and easily removed.

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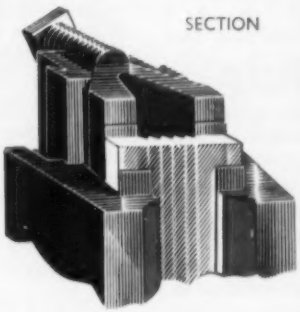
Write to your Klinger agent for descriptive leaflets and literature.



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Who's Building . . .

Next Construction Boxscore will appear in the July issue.

Phillips Heads Final Write-Off Grants

Commonwealth Refinery at Ponce

Work Launched to Increase New Puerto Rican Refinery

ON STREAM with its new 21,700-barrel-a-day refinery in Puerto Rico, Commonwealth Refining Company has awarded a contract to more than double the plant's capacity.

The Lummus Company, which designed, engineered and constructed the refinery, was selected to handle its expansion. Construction, due to be completed early in 1957, will increase thruput to about 55,000 barrels a day.

Capacity of the refinery's atmospheric- and vacuum-distillation facilities will be expanded by 33,000 barrels a day.

The project will double capacity of the catalytic-cracking and reforming equipment and increase catalytic-polymerization capacity from 980 barrels a day to 1450 barrels.

The cat cracker, licensed by Houdry Process Corporation, is a 26,000-barrel-a-day unit equipped with Lummus vapor-recovery equipment; the reformer, also a Houdry unit, has a 3730-barrel-a-day capacity. The poly unit was licensed by California Research Corporation.

Equipment at the refinery also includes a 1450-barrel-a-day sulfuric-acid alkylation unit equipped with an acid-regeneration system. Additional construction will give the plant a sulfur-dioxide distillate-treating unit with a daily capacity of 4100 barrels.

Designed to produce high-octane gasoline from Venezuelan and Middle East crudes, the refinery is located on Guayanilla Bay near Ponce. Its equipment also included treating and blending units.

ODM Approves Six Major Projects In Phillips Program

Office of Defense Mobilization approved a number of companies for rapid tax amortization certificates before the write-off program ended (**See What's Happening in Industry**). These included Phillips Petroleum Company, with a $15.6-million expansion of its Borger, Texas, refinery.

The company received certificates for distillation, cracking, alkylation, hydrogenation and fractionating facilities at Borger. The certificates will allow 50 percent on $8,300,000; 20 percent on $6,400,000; 100 percent on $550,000, and 65 percent on $350,000.

Phillips facilities to isomerize a blend of normal hexane and methylcyclopentane for production of aviation gasoline at Phillips, Texas, will be allowed 65 percent on $4,736,300; 45 percent on $1,522,700, and 15 percent on $30,000.

Another Phillips project cleared for a write-off was a 16,000-barrel-a-day catalytic-reforming unit at Kansas City, Kansas. This will be amortized at 65 percent on $4,180,000; 45 percent on $895,000, and 15 percent on $325,000.

Certificates also were issued for an 8000-barrel-a-day alkylation unit, a 6000-barrel-a-day isobutane isomerization unit, a catalytic cracker and expansion of existing Phillips facilities at Sweeney, Texas. These will be written off at 65 percent on $14,225,000; 45 percent on $6,185,000; 15 percent on $400,000, and 100 percent on $12,690,000.

And Phillips will be allowed to write off expansion of its natural-gasoline facilities in Crane County, Texas, at the fast rate of 65 percent on $959,000 and 40 percent on $118,000. The company can write off new research and development facilities at Bartlesville, Okla., at 40 percent on $3,118,705.

These were other companies receiving certificates:

- Standard Oil Company (Indiana)—3800-barrel-a-day butylene-alkylation unit at Sugar Creek, Wyo., 100 percent on $3,500,000; 50 percent on $2,475,000, and 15 percent on $19,000.
- Petrolite Corporation — 130,000-barrel-a-day desalting unit at Tide Water Associated Oil Company's new refinery

Who's Building . . .

under construction at Delaware City, Del., 65 percent on $171,250.

• National Cooperative Refinery Association—1450-barrel-a-day alkylation unit at its McPherson, Kansas, refinery, 100 percent on $1,150,000, and 45 percent on $250,000.

• Cities Service Oil Company—Construction of a 2060-barrel-a-day alkylation unit and residuum-cracking unit and expansion of existing crude-topping equipment at Ponca City, Okla., 65 percent on $4,500,000; 100 percent on $2,345,000, and 45 percent on $2,069,000.

• Shell Oil Company—Construction of $14-million refining facilities at Wood River, Ill., 65 percent on basic facilities and 45 percent on auxiliary facilities.

• American Gilsonite Company — A plant for processing gilsonite into 1500 barrels a day of gasoline and 300 tons of coke at Grand Junction, Colo., 65 percent on $6,865,000; 45 percent on $1,719,000, and 15 percent on $235,000.

• Bankline Oil Company—4000-barrel-a-day fluid coking unit at its Bakersfield, Calif., refinery, 65 percent on $1,962,000.

• The Standard Oil Company (Ohio) —Expansion of existing catalytic-cracking facilities at Lima, Ohio, 65 percent on $415,000 and 40 percent on $155,000.

• Republic Oil Refining Company—Conversion of thermal-cracking equipment at Texas City, Texas, and additional crude-topping facilities, 65 percent on $560,000. Write-off certificates for Republic also include expansion of its polymerization unit at Texas City, at 65 percent on $175,000.

• Aurora Gasoline Company—Expansion of a Muskegon, Mich., refinery from an 11,000-barrel-a-day capacity to more than 15,000 barrels, 65 percent on $2,463,000; 40 percent on $739,000, and 15 percent on $40,000.

• Pontiac Refining Corporation—5000-barrel-a-day catalytic-reforming unit and auxiliary facilities at Corpus Christi, Texas, 65 percent on $1,721,000, and 45 percent on $203,000.

• Cosden Petroleum Corporation — 2100-barrel-a-day catalytic-desulfurization unit at Big Spring, Texas; a 3900-barrel-a-day catalytic-reforming unit, and expansion of a catalytic cracker, 65 percent on a total of $3,487,000 and 45 percent on $500,000.

• Salt Lake Refining Company—Expansion of crude-distillation unit at Salt Lake, 65 percent on $249,000 and 40 percent on $1000.

• Continental Oil Company—Combination naphtha-hydrotreating and catalytic-reforming unit at Ponca City, Okla., 65 percent on $2,311,374 and 45 percent on $442,200.

The British Petroleum Company, planning to increase the crude capacity of its Kent refinery by 50,000 barrels a day, has awarded the contract for engineering offsite facilities required for the project.

The work will be done by two British concerns—W. J. Fraser & Company, Ltd., and The Power Gas Corporation, Ltd.

Power Gas Corporation also received the contract for another addition to the Kent refinery. South Eastern Gas Board picked the firm to handle construction of its proposed oil-gasification plant.

British Petroleum will spend about $55 million for its expansion program.

On the Isle of Grain, near London, the Kent refinery now is processing some 90,000 barrels a day. The expansion, consisting of additional distillation equipment and other processing plants, will raise this figure to about 140,000 barrels.

The program, to be completed late in 1957, will be in addition to a 2600-barrel-a-day aviation-gasoline plant to be built at Kent at a cost of $18 million.

The unit the South Eastern Gas Board is installing at the British Petroleum refinery will be Britain's first cyclic catalytic gas-making installation, and it is said to be the world's largest.

The unit, to be in production by fall 1958, will produce gas at a rate of 15 to 20 Mmcf. a day, using between 1200 and 1400 barrels of oil. Eventually, four such units will be installed raising the plant's daily output of gas to 80 Mmcf.

The product will supplement existing gas supplies distributed through the South Eastern Gas Board grid system from Sittingbourne, Kent, to Guilform, Surrey.

This type plant previously has manufactured gas from heavy oil at York and from heavy oil and light distillates at Sydenham. Other Segas plants are being built in the U. K. and Europe.

The Kent plant will use refinery residual products such as heavy and light fuel oils, light distillate and LP-gases.

Continental Oil Company is about to complete a $1-million expansion of its refinery at Billings, Mont. The new installation, a desulfurizer-catalytic reformer, will enable Conoco to produce high-quality distillate fuels from the high-sulfur crude refined at Billings.

The unit was licensed by Union Oil Company of California. It was installed by The Stearns-Roger Manufacturing Company, and the refinery staff handled engineering.

Esso Standard Oil Company is getting ready to spend some $40 million for improvement and extensions to the plant and equipment at its Baton Rouge refinery. Two years will be required to complete the program, part of which already has been started.

Projects will include facilities for increasing production of aviation gasoline, lubricating oil, wax, thylene and butadiene.

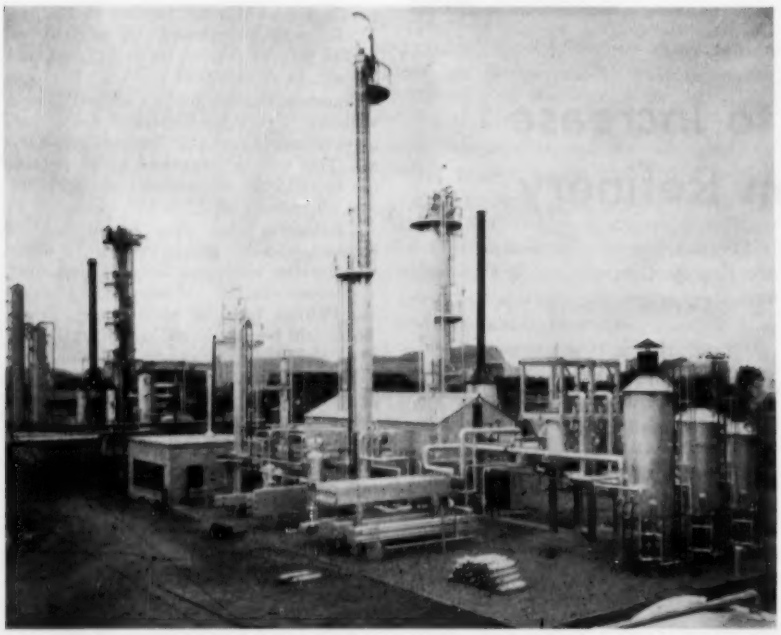
Gulf Oil Corporation has completed two major additions to its refinery at Port Arthur, Texas. One is a 68,000-barrel-a-day fluid catalytic-cracking unit installed by The M. W. Kellogg Company. The other is a 100,000-barrel-a-day crude-topping unit built by Arthur G. McKee Company.

The Atlantic Refining Company will build an absorption gasoline plant, capable of handling up to 25 Mmcf of gas a day, near Crane, Texas. The plant will remove salable products in the form of natural gasoline, butane and propane.

Authorization of the new plant came from three co-owners, Phillips Petroleum Company, Continental Oil Company and Chicago Corporation. Atlantic will operate the plant.

Societe des Usines Chimiques Rhone-Poulenc has been granted a license by Phillips Petroleum Company for the exclusive use in France of the Phillips-developed process for making polyethylene.

The company will join with three other French concerns in building a plant for



Second Unit on Stream—

Husky Oil & Refining, Ltd., has brought its second new catalytic-reforming unit into operation. The unit, a Catformer, is producing 95-octane reformate from a full boiling range, untreated crude naphtha at the Husky's Moose Jaw, Sask., refinery. The company's first Catformer, at Fort Williams, Ont., went on stream in July, 1955, and is still on its initial run. The two units were built during Husky's revamping and expanding of these newly-acquired refineries. Both were constructed by The Fluor Corporation of Canada and are operated under license with The Atlantic Refining Company.

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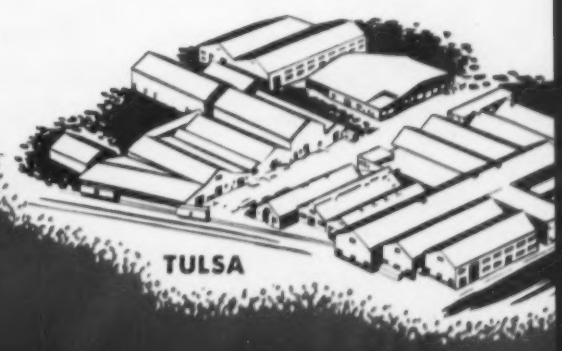

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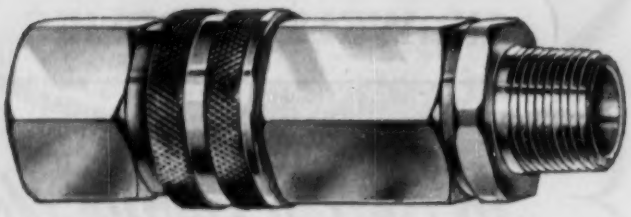

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Who's Building...

the production of plastics at Gonfreville. The other companies are Establissements Kuhlmann and Compagnie Francaise de Raffinage (C. F. R.)

The plant will be located adjacent to the C. F. R. refinery at Gonfreville. Feedstocks for ethylene production will be supplied from the refinery.

Stauffer Chemical Company is planning to build a new sulfuric-acid plant, which will cost about $2 million at Dominquez, Calif. Construction is expected to start immediately, with the new installation going into full production early in 1957.

Gulf Oil Corporation will complete two Gulfining units at its Port Arthur, Texas, refinery in September 1956, and two more units will be completed at the company's Philadelphia refinery early in 1957.

The units will be used to remove sulfur compounds from distillate and otherwise upgrade the product with hydrogen produced by catalytic reformers. Combined capacities of the four units will total 90,000 barrels a day.

Petroleos Mexicanos is planning to build a 1000-barrel-a-day lube-oil plant at its Minatitlan refinery. Construction is expected to start late in 1956, with the plant due to go into operation before the end of 1957.

El Paso Natural Gas Products Company is planning to build a refinery near Gallup, N. M. Capacity of the plant was not announced.

The new refinery will be built adjacent to the company's existing Wingate fractionation plant to use butane and natural gasoline produced at the Wingate plant. It also will process crude from the Four-Corners area.

Process equipment will include a crude-distillation unit, vacuum unit, catalytic cracker, alkylation and reforming facilities.

A contract for process engineering on the new plant has been let to Universal Oil Products Company. Construction is expected to take about 18 months, with completion scheduled for Fall 1957.

The new products company, a subsidiary of El Paso Natural Gas Company, operates a 4000-barrel-a-day refinery at Brickland, N. M., and two refineries in northwestern New Mexico.

One of these is a 1000-barrel-a-day topping unit at Bloomfield, and the other is a 3000-barrel-a-day refinery at Prewitt. Capacity of the latter plant is being increased 1000-barrel-a-day.

D-X Sunray Oil Company will double the size of the research laboratories at its West Tulsa refinery. Construction will start in May, with completion expected in January 1957.

Facilities to be expanded include the experimental, analytical and physical-inspection laboratories. New equipment will be added and additional space provided for offices.

Esso, A. G., West German affiliate of Standard Oil Company (New Jersey), is picking the site for a 60,000-barrel-a-day refinery in the Cologne area. The refinery,

under consideration for some time, is scheduled for production in 1959.

It will bring Standard's German refining capacity to 100,000 barrels a day. The company's present refinery at Hamburg has a daily capacity of 40,000 barrels.

Esso has placed on stream a new Hydrofining unit at the Hamburg refinery. The unit, costing $3 million, has a design capacity to treat 6000 barrels of distillate a day.

Carbide & Carbon Chemicals Company, division of Union Carbide & Carbon Corporation, is planning an expansion of its facilities at Seadrift, Texas, increasing ethylene-glycol and ethylene-oxide capacities. Based on ethylene oxide, the new ethylene-glycol capacity will be 65 million pounds a year; ethylene-oxide capacity will be expanded to 200 million pounds a year.

Phillips Petroleum Company is operating a new gasoline plant near Lindsey, Okla. Jointly-owned with Magnolia Petroleum Company, the plant is designed to process 60 Mmcf. a day. Initial volume will run about 20 Mmcf.

Mobile Oil Company, Ltd., Socony Mobil Oil Company's British affiliate, has a new Sovaformer under construction at its Coryton refinery. The unit, to handle 6000 barrels of naphtha a day, will be completed in July. Bechtel International, Ltd., is performing the engineering and construction.

Petroquimica, S. A., a new concern financed by private U. S. and Mexican capital, plans to build two $6-million anhydrous-ammonia plants. This marks the first of a petrochemical industry in Mexico.

The first plant will be at Guaymas, on the northern west coast. Due for completion in about two years, the plant will have an annual capacity of 35,000 tons.

Petroleos Mexicanos, the government oil agency, also is expected to enter the petrochemical field, with construction of new facilities at its Atzcapotzalco refinery near Mexico City.

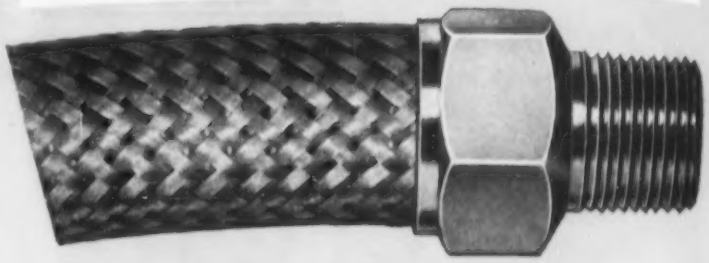
National Cooperative Refining Association, planning to install alkylation facilities at its McPherson, Kansas, refinery, has awarded Refinery Engineering Company the contract for design and construction of a 1500-barrel-a-day hydrofluoric-acid unit.

The unit, which is expected to cost $1.2 million, has been scheduled for completion in October 1956. Licensed by Universal Oil Products Company, it will be operated in conjunction with the catalytic-cracking plant and a recently-completed Platformer.

Southland Oil Company is planning to build a refinery near Tampa, Fla., with a capacity of 15,000 barrels a day. Plans call for this to be increased later to an eventual 60,000 barrels a day.

The initial plant, financed by Texas capital, is expected to cost more than $10 million.

Process equipment will include crude distillation, catalytic cracking, catalytic



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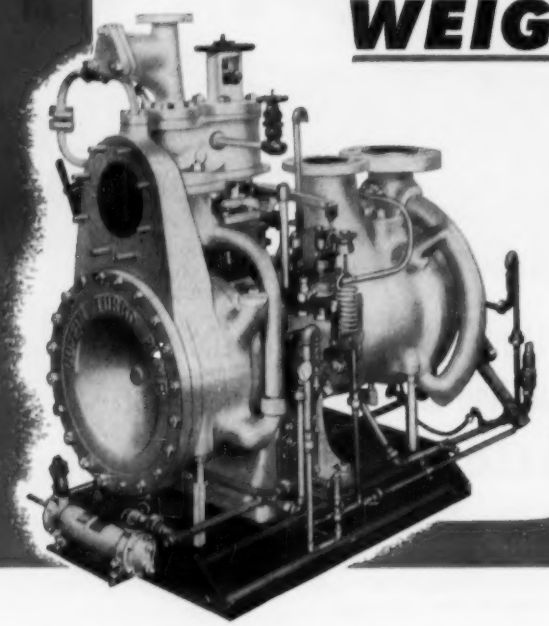

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reforming and alkylation. The plant will turn out high-octane gasoline jet fuel, asphalt and other petroleum products.

Two other refineries have been announced for Florida. Seminole Oil Company is planning a 20,000-barrel-a-day plant at Fort Pierce. And Sunshine States Refining, Inc., has a fast write-off certificate for a 10,000-barrel-a-day refinery near Tampa.

The Texas Company will build a new $12-million plant at its Lockport, Ill., refinery to produce anhydrous ammonia and ammonia derivatives. The plant will have a daily capacity of 180 tons.

Delhi-Taylor Oil Corporation, with refineries at Corpus Christi and Port Isabel, Texas, is planning to install additional processing facilities. Construction at one or both of the refineries is expected to start late in 1956.

Caltex Petroleum Maatschappij (Nederland), N. V., is negotiating for enough land to double the area of its Pernis refinery. The additional land would be used for refinery additions and construction of a laboratory.

Empressa Nacional Petroleos, Colombian government-owned oil agency, is planning a $4-million expansion of the propane-recovery facilities at its Barranca Bermeja refinery.

Deutsche Vacuum Oel, A. G., is expanding capacity of its Bremen-Oslebshausen refinery. Due to be completed in 1957, construction will boost capacity of the refinery from its present daily rate of 15,300 barrels to about 25,000.

The project will add a two-stage distillation plant, a 3200-barrel-a-day catalytic reformer, a 4800-barrel-a-day diesel-oil desulfurization unit and facilities for a sulfur plant.

The company is the West German affiliate of Socony Mobil Oil Company. The new reformer will use the Sovaforming process, and the desulfurization plant will use Sovafining.

The Ohio Oil Company will operate a $200,000 low-temperature, natural-gas recovery plant at Lance Creek, Wyo., to be built jointly with Continental Oil Company and Argo Oil Corporation.

The plant will replace Conoco's Lance Creek unit which is considered obsolete. Construction will be started on the site of the old unit as soon as it is dismantled.

Designed for a daily capacity of 5 Mmcf., the new plant will process 4 Mmcf. initially, turning out 5200 gallons of gasoline, 5200 gallons of propane and 10,300 gallons of butane.

American Synthetic Rubber Corporation will increase capacity of its copolymer plant at Louisville, Ky., by 50 percent, raising output to about 68,000 tons a year.

Contract for engineering and constructing the new facilities went to Walter Kidde Constructors, Inc. The work, to be started immediately, is scheduled for completion early in 1957.

Continental Oil Company is planning a further expansion of its Ponca City, Okla., refinery to include a catalytic reformer and

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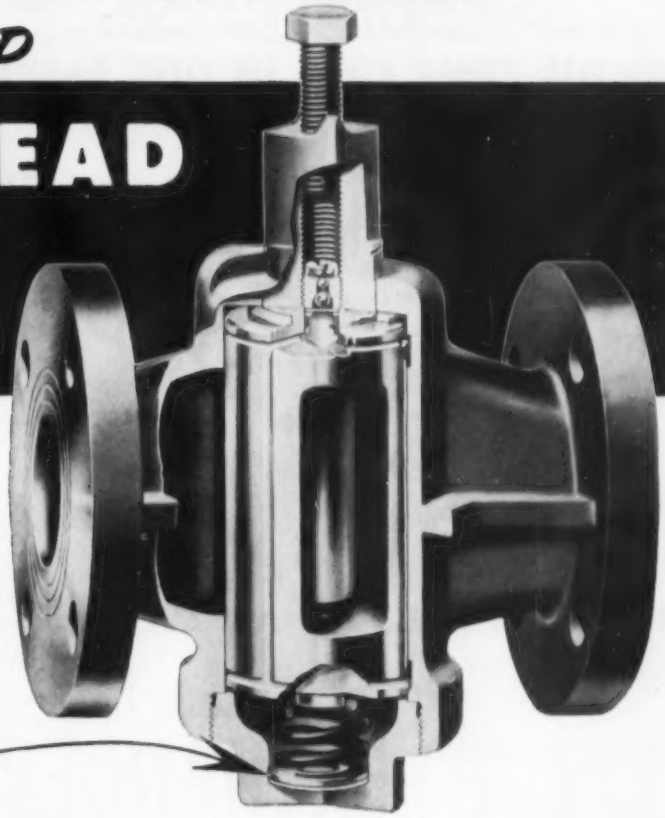

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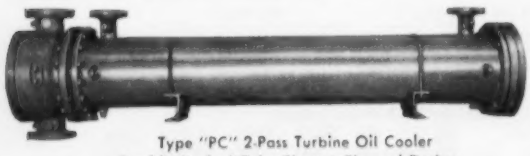

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auxiliary facility with a total capacity of 11,000 barrels a day. The program will cost about $3 million.

Construction of the new units will be started this summer, with their completion scheduled for mid-1957. The construction contract went to The M. W. Kellogg Company.

Sinclair Refining Company will build a catalytic-reforming unit at its Wood River, Ill., refinery. Design work has been started, and the new reformer is expected to be in operation within a year.

The unit, with a rated daily capacity of 7500 barrels, will be the fourth reformer built by Sinclair. Three larger units are in operation at the company's Marcus Hook, East Chicago and Houston refineries.

Assam Oil Company, Ltd., has suggested Calcutta as the site for India's fifth refinery. The suggestion was made in a proposal to the government, seeking authority to build another Indian plant. The company, a subsidiary of The Burmah Oil Company, Ltd., already operates a 5750-barrel-a-day refinery at Digboi. Details of the projected Calcutta plant were not known.

Consumers Cooperative Refinery, Ltd., has a $2-million expansion in prospect for its Regina, Sask., refinery. The Canadian concern is planning a 30-percent increase in the plant's capacity, to boost daily output from 12,500 barrels to more than 16,000. Final details will not be available until spring 1957.

Societe du Caoutchouc Butyl, planning synthetic-rubber facilities in France's Basse-Seinne region, has been issued a license by Esso Research & Engineering Company for the first butyl-rubber plant to be built overseas.

The plant, to have an annual capacity of 20,000 tons, will be built at Port Jerome, near Le Havre. Engineering has been started, and construction is expected to be completed in 1958.

The company, a new corporation formed by ten French companies, also was licensed to use Esso's technique for recovering isobutylene from refinery gases. This will enable the company to recover isobutylene from the petroleum gases of nearby refineries at Gonfreville and Port Jerome.

Suntide Refining Company plans to build a unit to produce 100-octane gasoline at its Corpus Christi, Texas, refinery. The unit, a Rexformer, will have a capacity of about 15,000 barrels a day. About 65 percent of its output will be 100-octane gasoline, and the remainder will be 93-octane fuel.

In addition, Suntide is building a unit for the manufacture of such petrochemicals as toluene and benzene.

The company already is nearing completion of a program to expand its total refining capacity to more than 65,000 barrels a day. The refinery previously had a capacity of 50,000 barrels.

Republic Oil Refining Company has awarded the contract for design, engineering and construction of a new crude-distillation unit at its refinery in Texas City, Texas. The work, to be done by Refinery Engineering Company, will include con-

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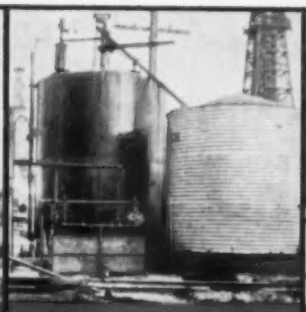

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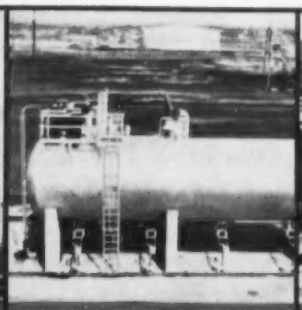

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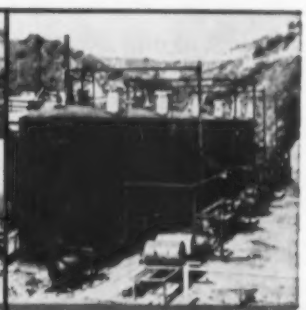

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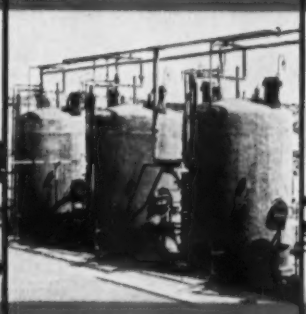

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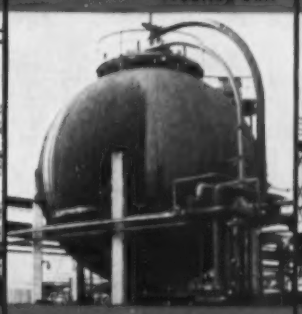

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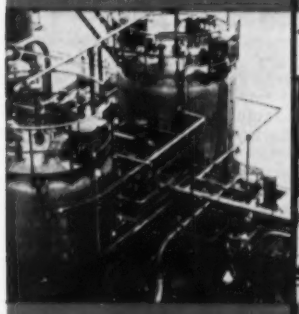

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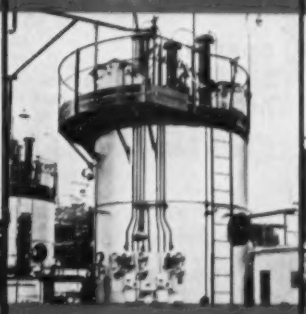

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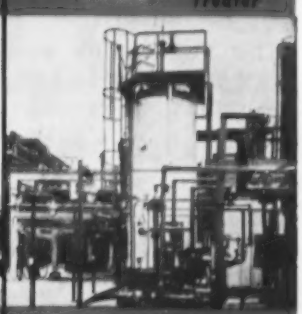

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struction of a new control room which ultimately will serve four process units.

The new crude unit will use the area and some equipment of a thermal-cracking unit which republic no longer uses. Following start-up of the new crude unit, older and smaller units will be shut down or converted to other processes.

Shell Chemical Company, Ltd., drawing on the ammonia-manufacturing experience of its affiliaties in the U. S. and Netherlands, will build two plants at the Shell Haven refinery in Essex for the manufacture of ammonia-based fertilizers. Together, the plants are expected to cost $30 million.

The first, an $18.5-million installation, will convert refinery gases or other petroleum hydrocarbons into ammonia and nitric acid. The plant will be completed by 1958, with an annual capacity of 75,000 tons.

The other plant, which will be built if land is available, will use 60,000 tons a year of ammonia from Shell Haven for production of ammonia-based fertilizers. This unit will cost about $12.5 million.

Midland Cooperatives, Inc., is nearing completion of a 3000-barrel-a-day Platformer at its Cushing, Okla., refinery. Procon, Inc., is installing the new unit.

Hercules Powder Company will build a new plant to produce 7 million gallons of methanol a year. The plant, to cost more than $2 million, will be built at Louisiana, Mo., where Hercules operates an anhydrous-ammonia plant and is completing construction of a pentaerythritol and formaldehyde plant.

A large part of the methanol output will be used by the company in its adjacent new PE plant. The new methanol plant will integrate with present facilities in the manufacture of ammonia.

For the first time in the U. S., the Swiss Inventa process will be used for the production of methanol.

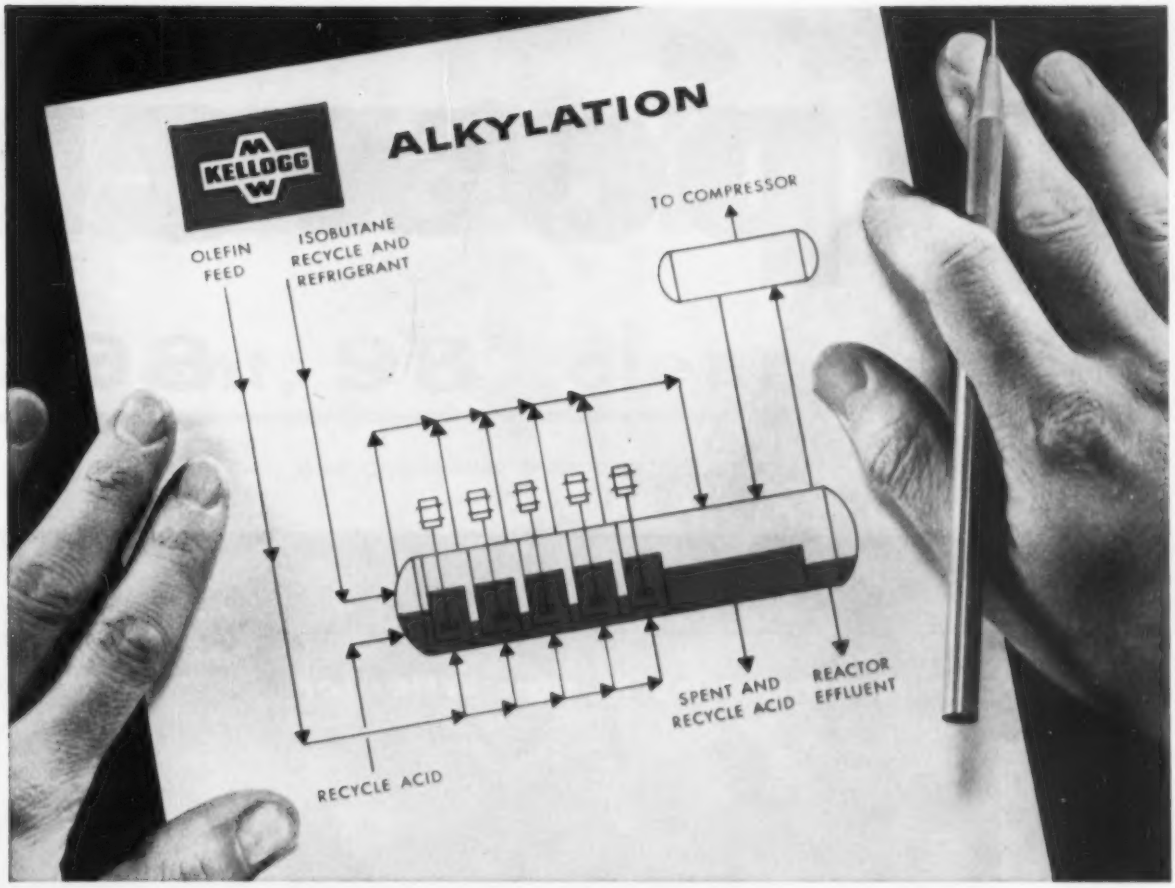
Construction of the plant will be started before summer 1956, with completion scheduled for the second quarter of 1957. Contract for the engineering and construction was given to Vulcan Copper and Supply Company.

The pentaerythritol plant, a $6-million project, is scheduled for completion late in 1956. It will double the company's pentaerythritol capacity, turning out 24 million pounds of pentaerythritol a year and 100 million pounds of formaldehyde. The existing ammonia plant will continue in operation at its present rate of 40,000 tons a year.

Mene Grande Oil Company, with Creole Petroleum Corporation, will build a cycling plant in Venezuela's San Joaquin area. The cost is expected to run some $2.3 million.

Sinclair Refining Company will build a $1.3-million hydrogen-finishing unit at its East Chicago refinery. The unit will use by-product hydrogen from a catalytic reformer to finish lubricating oils.

Sun Oil Company will further expand its research center at Marcus Hook, Pa., with construction of a second section of the main laboratory. The unit is scheduled



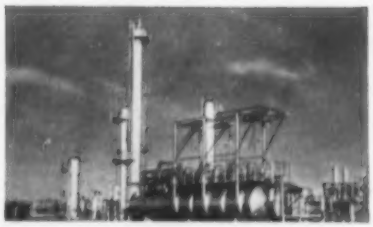
Lower Investment in Recycle Equipment with Multiple Stage Cascade Reactor

With more and more refiners expanding their alkylation capacity, attention is focussed again on the equipment economy and isobutane efficiency of M. W. Kellogg's cascade reactor as compared with earlier jet-type systems.

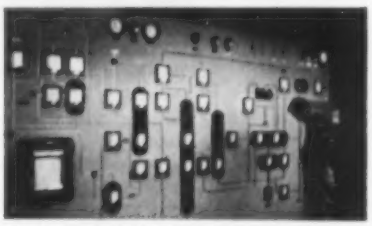
In a 2,500 BPD alkylation plant, for example, Kellogg's five-stage design reduces the number of reactors required from four to one! Instead of the approximate 12,800 BPD of isobutane recycle needed for the four individual reactors, Kellogg's single reactor requires only 4,500 BPD recycle!

In addition, the isobutane tower is reduced from 13½ to 7 feet in diameter. Exchangers, condensers, reboilers, pumps, piping, and other auxiliary equipment are proportionately smaller. And one centrifugal compressor replaces three reciprocating machines.

M. W. Kellogg welcomes the opportunity to discuss with you the improvements it is continuously making in its alkylation techniques. Recent examples are a cascade reactor with *seven* reaction zones, and the new bauxite process—developed jointly with D-X Sunray Oil Company—which reduces corrosion and fouling of fractionating units.



A recent installation of M. W. Kellogg's sulfuric acid alkylation process clearly shows the unique cascade reactor.



Control panel for units shown in the other photograph, with instruments identified by color-coded silhouettes.

Refinery Process Division

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This combination provides the refiner with a most effective means for the catalytic reforming of low-octane naphthas into high-octane motor fuel components.

Powerforming, developed by Esso Research and Engineering, has already proved its outstanding performance on three units which are now in successful operation. Fourteen more are under construction or in the design and planning stage.

The first Powerforming unit, shown at the left, in operation since May 1955 was designed and constructed by Foster Wheeler for Esso's Baltimore refinery. FW is currently providing mechanical design and construction for two more Powerforming units – a 20,000 barrel per day unit at the Bayway refinery and a 7,000 barrel per day unit at Imperial's Halifax refinery where Foster Wheeler is also building Crude Distillation, Fluid Catalytic Cracking, Polymerization and Treating units. For further information write to *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

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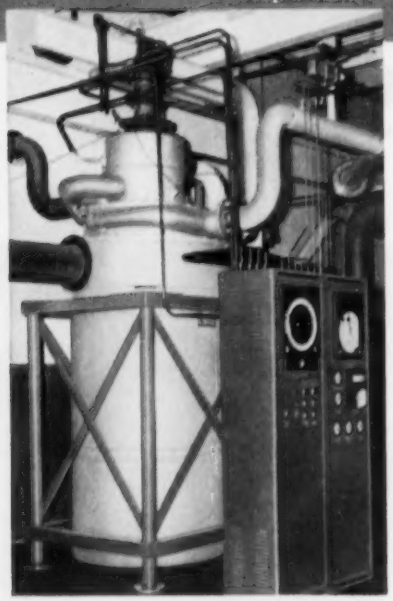

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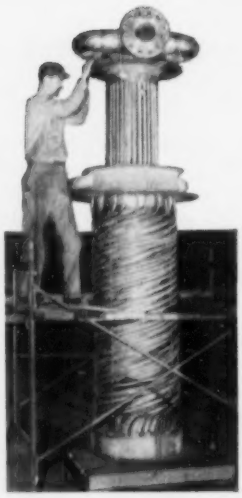

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for completion in 1957. Cost of the plant and equipment is expected to cost $1,375,000.

With this unit, the company will consolidate all its chemical research and development activities in one location. Technical personnel and research equipment will be transferred from the laboratory at Norwood, Pa., where the company has been carrying on basic research.

Phillips Petroleum Company, with Magnolia Petroleum Company, has built a natural-gasoline liquids-extraction plant near Lindsay, Okla. Phillips will operate the jointly-owned plant. It has a daily capacity of 50 Mmcf.

Richfield Oil Corporation has awarded contracts for engineering and construction of two turnkey projects at its Wilmington, Calif., refinery.

The contracts went to Macco Corporation. The two units are a diethanolamine-regeneration unit and a water-reclaiming unit.

These plants are expected to increase substantially Richfield's capacity for recovering hydrogen sulfide. Cost of the projects will run about $500,000.

The California Oil Company will increase the catalytic-reforming capacity of its Perth Amboy, N. J., refinery by 25 percent, adding an 800-horsepower compressor, new heat exchangers and pumps. Primary contractor for the work is Bechtel Corporation.

Indian Government, long considering construction of Asia's first synthetic-petroleum plant, has taken up the appointment of consultants to recommend a location for the plant.

Plans have been approved in principle to build a 6000-barrel-a-day plant to produce about 10 percent of the country's requirements. Output would be divided into 4300 barrels a day of motor gasoline and 1700 barrels a day of aviation fuel.

National Petroleum Corporation of Cuba, recently organized by U. S. and Cuban interests, will start construction on a $10 million refinery at Cienfuegos. The new plant, expected to be completed late in 1956, will process 5000 barrels a day.

Shell Oil Company, Ltd., will build facilities at its Montreal East plant for Canada's first production of methyl ethyl ketone and secondary butyl alcohol.

Construction will begin immediately. When the project is completed late in 1956, production will be more than sufficient to supply the entire Canadian market.

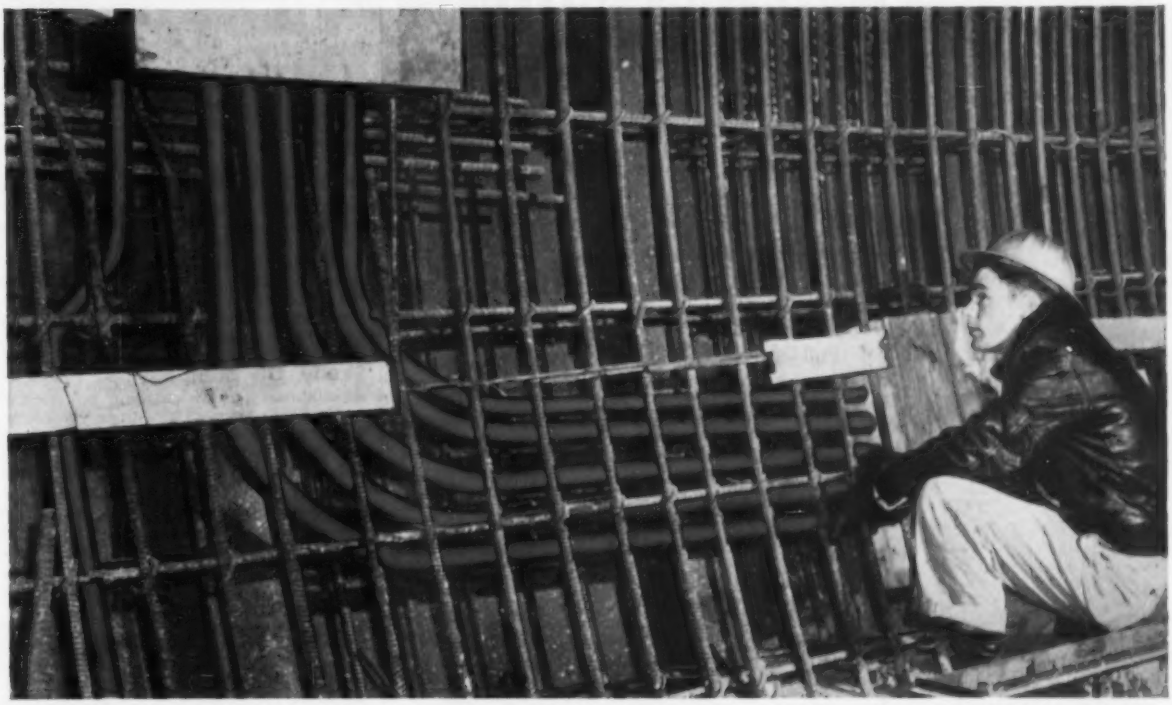
The facilities are designed to allow the company to branch out into other petrochemical production. Raw material for the new units will be butylene drawn from Shell's Montreal East refinery.

W. R. Grace & Company will build a 50-million-pound-a-year polyethylene plant at Baton Rouge, La. The new plant, to cost about $18 million, will be built in two stages.

The first, a $1-million semiworks plant to produce polyethylene and other poly-

For more data on advertised products, use Readers' Service Cards, last page.

Power for the new 7,650-foot Baltimore Harbor Tunnel will be protected by EVERDUR Electrical Conduit



Everdur Electrical Conduit, nominal size 1½", connecting control box to sidewalk manhole—all conduit to be embedded in concrete.

A section of Everdur Conduit in the roadbed slab protects the vital traffic control system and air duct lighting.

THE BALTIMORE HARBOR TUNNEL†, under the Patapsco River, scheduled for completion in 1957, will be the largest "trench-type" tunnel ever built. Twin-tube sections are built on dry land, launched and concreted almost to zero buoyancy, then sunk in place and joined underwater by divers.

Power for traffic signals, alarms, air duct lighting, and shaft lighting circuits for this great tunnel will be protected by Everdur* Electrical Conduit—made from one of Anaconda's copper-silicon alloys. Everdur never rusts—offers high resistance to other types of corrosion. It provides dependable year-after-year protection—wherever water and corrosive atmospheres are a problem—or where conduit must be buried or embedded in concrete. Everdur is also tough—stands up under movement and vibration.

For detailed information, write: The American Brass Company, Buffalo Division, Buffalo 5, New York. In Canada: Anaconda American Brass Limited, New Toronto, Ontario.

*Reg. U.S. Pat. Off. 56134

†Built by Maryland State Roads Commission; Merritt-Chapman & Scott Corp., General Contractors; Singstad & Baillie, Contracting Engineer; J. E. Greiner Co., Consulting Engineer.

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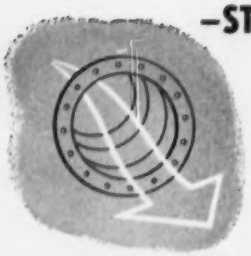
Only Rotovalves give you all these features:



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Full line opening means less head loss, lower pumping costs.

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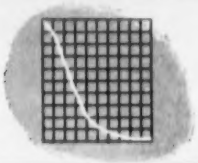
Hydraulic imbalance and mechanical design mean 1 man can close as fast as required. Less power needed in mechanical or electrical operation.



GREATEST INITIAL SHUT-OFF
Rotovalve 55% closed at 25% stroke, and 92% closed at 50% stroke. In comparison, gate valves only 18% closed at 25% stroke and 43% closed at 50% stroke.

MOST CONTROLLED CLOSING TIME
Closing as quickly as one second or as slow as needed. Fast initial closing limits reversal of flow.

MOST POSITIVE CLOSING
Drop-tight, positive closing. Self-purging, monel-to-monel seating. Pressure-tight bolted head, stuffing box, and machined and lapped seats.

In addition to all these features typical of SMS engineering, Rotovalves have a flexibility that makes them suitable for any type of operation, any method of control, or any sort of location.

For detailed information about SMS Rotovalves, Ball or Butterfly Valves, see our local representative or write to the S. Morgan Smith Company, York, Pennsylvania.

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Who's Building...

mers, will go into operation in mid-1956. The commercial plant will be completed about a year later.

Ethylene for the new facilities will be supplied from Esso Standard Oil Company's nearby refinery.

Grace will use Phillips Petroleum Company's low-pressure polyethylene process. The Fluor Corporation, Ltd., is contractor for both phases of the project.

U. S. Oil & Refining Company has construction underway on its 15,000-barrel-a-day refinery at Tacoma, Wash. Work has been started on a three-stage vacuum still, a thermal-cracking unit and a propylene-polymer plant. J. B. Gill Company has the contract to install these units. Contracts are still to be let for a catalytic reformer and Unifining plant.

Skelly Oil Company has completed an 800-barrel-a-day catalytic reformer at its Denver refinery. The unit, a Platformer, was engineered and built by Skelly engineers. It was installed by Stearns & Rogers Manufacturing Company.

Cosden Petroleum Corporation has started construction on its $3-million project to make styrene at Big Spring, Texas. Completion of the new petrochemical plant, an addition to the Cosden refinery, is scheduled for November 1956.

The facility will produce 20 million pounds a year. It will be the first plant to use "ultra fractionation" for recovery of ethyl benzene. In the past, it has been necessary to alkylate benzene with ethylene to make ethyl benzene.

Production of styrene by this process will require towers 200-feet-high. They will be the tallest fractionating columns ever built.

Lake Charles Chemical Company, a newly-organized corporation, plans to build a $6,250,000 coking unit at Lake Charles, La. The coking unit will be operated by Continental Oil Company, as an integral part of Conoco's Lake Charles refinery.

Designed to upgrade refinery stocks presently used in making heavy fuel oil, the unit will produce about 85,000 tons of coke a year for industrial use and 4200 barrels a day of refinery stock for making motor gasoline.

Construction will be started within the next few weeks, with the unit scheduled for completion late in 1957.

Onyx Refining Company has been issued a fast tax write-off certificate for additional refining facilities at its Abilene, Texas, refinery. The company will be allowed 35 percent on $73,874 for auxiliary equipment.

Borden Company is building a polyvinyl-chloride resin plant at Leominister, Mass. It is scheduled for completion in June 1956 and will have an annual capacity of 12 million pounds. The new plant will adjoin the company's present facilities to produce polyvinyl alcohol and polyvinyl acetate.

Esso Standard, S. A., has awarded the contract for construction of a virtually new refinery on the site of its existing

PETROLEUM CHEMICALS DIVISION

NEWS

May ★ One of a Series of Bulletins for the Petroleum Industry ★ 1956

ONE COMPLETE LINE

Only Du Pont offers you a *complete* line of additives . . . for gasoline, for diesel and heating fuels, and for lubricating oils. Du Pont also offers grease stabilizers and dyes. To bring yourself up to date on the benefits of these products, read about them below and on the next page.

1. AN ASHLESS heating and diesel fuel oil additive. (See below.)
2. A NEW TYPE of lube oil additive that fills the growing need for low-duty detergency. (See below at right.)
3. COPPER CONTAMINATION in a wide variety of petroleum products can be controlled. (See article on Du Pont Metal Deactivator on next page.)
4. COLOR is adding new sales advantages to many petroleum products. (See next page.)
5. GREATER ECONOMY can result from purchasing Du Pont additives in carload lots. (Read about it on the next page.)
6. MULTI-PURPOSE greases for high temperature service require additional stability. (The Du Pont grease stabilizers written up on the next page can help you achieve it.)

ASHLESS additive to help you avoid oil burner and diesel troubles

Since it is a nonmetallic ashless additive, Du Pont Fuel Oil Additive No. 2 (FOA-2) does not leave a metallic ash deposit that can foul the operation of oil burner electrodes and stack controls. Also, it can be used in diesel fuels without any danger of contributing to exhaust sparking.

Many other advantages

Added to freshly prepared heating oil stocks at the refinery, FOA-2 retards the formation of insoluble residues in storage and customer tanks. It also reduces the particle size of any residues that are formed and helps to clean out any sludge deposits that might previously have formed in oil burner systems.

In diesel fuels, its stabilizing and dispersant action can help prevent injector sticking and filter plugging. In this way, FOA-2 provides a means of making economy grade, cat-cracked fuels highly acceptable for diesel operation.

New setup to expand customer service to refiners on Du Pont additives

The continuing upsurge in both volume and quality of petroleum products has increased the demand for all types of chemical additives. To meet this growing demand, the Du Pont Petroleum Chemicals Division has recently followed the lead established for TEL and streamlined its sales and technical service setup for the handling of all Du Pont additives.

J. J. MIKITA, right, Sales Manager, additives, and RICHARD O. BENDER, an Assistant Director of the Petroleum Laboratory, head up the new Petroleum Chemicals Division additives sales and technical service groups respectively.

To meet your need for low-duty lube oil detergents

Du Pont Lube Oil Additives 564 and 565 were especially developed to give effective detergency to motor oils for low-duty, around-town driving conditions. In addition to their detergency action, they will also add a substantial amount of your desired viscosity-index improvement.

Since a large part of the average motorist's driving is in stop-and-go city traffic, these unique additives offer you a strong promotional appeal for your motor oils.

•

A group under Mr. J. J. Mikita will have charge of the sale of Du Pont Metal Deactivator, gasoline antioxidants and dyes, fuel oil and lube oil additives, and grease stabilizers. In his former capacity as director of the Du Pont Petroleum Laboratory, Mr. Mikita had unusually broad experience in the development and application of all types of petroleum additives.

Mr. R. O. Bender, who has also been closely associated with the development of many Du Pont additives, will now be headquartered at the Du Pont Petroleum Laboratory. There, as an assistant director of the Laboratory,

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OVER

DU PONT

PETROLEUM CHEMICALS DIVISION
NEWS

DU PONT

CONTINUED *New Service Setup*

he will be able to closely coordinate the Laboratory's work with technical service for customers.

The new setup will provide thoroughly experienced personnel ready at all times to help refiners on both technical and commercial problems concerning the use of additives.

Together, these groups will devote their entire energies toward helping refiners make the most efficient use of Du Pont's complete line of additives for gasoline, diesel fuel, heating oil, lube oil, grease and other products.

Du Pont Metal Deactivator has wide range of valuable applications

In addition to gasolines, the list of products that can be improved with Du Pont Metal Deactivator (DMD) includes diesel fuels, home heating oils, kerosines, jet fuels, turbine oils, and greases.

Wherever copper contact is a possibility, there is danger of contamination and gum formation. But in most cases, a very small amount of DMD will supply adequate protection against the harmful effects of copper.

To help you take advantage of the benefits of Metal Deactivator in many different products, Du Pont offers comprehensive technical services. And these services are geared to your own individual needs and manufacturing operations.

Convenient laboratory help

The facilities and experience of the five Du Pont regional laboratories are an important part of these services. The laboratories may be able to help you put your whole additives program on a more economical basis.

For example—because combinations of DMD and other Du Pont additives often work more efficiently than one additive alone, the Du Pont laboratory recommendations can help you achieve your desired stability with less additive . . . often at a substantially lower treating cost.

Color helps you sell, identify, add interest to MANY petroleum products

Color is becoming a bigger factor in our everyday lives . . . and in the competitive struggle for sales. You see it in the cars on the street, in home decorating, in sport shirts at the beach.

It's important in petroleum products, too. Leaded gasolines have always been dyed. And many refiners have used gasoline dyes to match their pumps, station trim and brand identification signs. Many use it for sales promotion purposes in their motor oils, also.

TO GET the best results with Du Pont additives, you are always welcome to use the services of our conveniently-located regional laboratories.

Now greases and fuel oils are becoming more colorful. And the advantages of this go beyond the promotional value. Colored greases help service station personnel and industrial lubrication engineers identify the products and check their work. Fuel oils and other products can be readily identified by grade during pipeline shipments and at other points by the simple addition of color.

For adding these advantages to *all* your products, Du Pont offers a complete line of oil-soluble dyes—yellow, orange, red, blue and bronze. Their color stability is outstanding. And they are highly concentrated for economical use.

Grease stabilizers to meet varying requirements

As operating speeds and temperatures are pushed higher, grease stability is of increasing importance.

Du Pont "Ortholeum" 300 is highly effective as a metal deactivator, as well as an antioxidant. This quality is especially important in heavy-duty industrial greases which come in contact with bearings containing brass. It also provides unusually good resistance to color deterioration.

Du Pont phenyl-alpha-naphthylamine gives excellent results in most non-catalyzed systems. Where operating conditions are not too severe and competitive pricing is important, it can be used to increase stability at relatively low cost.

To help you save on cost of additives . . .

Du Pont additives are available in carload lots.

With Du Pont Antioxidant No. 22, for example, you can save about 6% by purchasing it in tank car lots. Such a saving can mean an important profit advantage to you. And we will be glad to ship these carload lots in special tank cars, equipped with steam coils to facilitate easy unloading.

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. . . *through Chemistry*

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A-1736

Printed in U. S. A.

Who's Building. . .

8500-barrel-a-day Belot plant in Havana. The new refinery, to be completed late in 1957, will process about 35,000 barrels a day.

Esso Standard is the Caribbean affiliate of Standard Oil Company (New Jersey). Under the program, it is expected to spend some $30 million for expansion and modernization of the Cuban refinery.

Work will involve the addition of new crude-distillation equipment, fluid catalytic cracking, catalytic polymerization, Hydrofining, Powerforming and related facilities.

Contract work will be handled by Arthur G. McKee & Company and Raymond Concrete Pile Company, under a joint-venture relationship with McKee carrying full responsibility. Processes to be used are those of the affiliated Esso Research & Engineering Company.

The British Petroleum Company, Ltd., will add a new 8000-barrel-a-day thermal reformer to its refinery at Aden. Also the company is extending the refinery's water-cooling supply and a liquid-petroleum-gas plant is about to go on stream.

Sun Oil Company is planning two new catalytic-reforming units—one at its Marcus Hook, Pa., refinery and the other at Toledo. Also at Marcus Hook, the company will build a desulfurization unit to treat reformer feed stocks and expand the refinery's wax capacity by 700 tons a month.

The new reformer at Toledo will be equipped with extraction facilities to separate benzene and other aromatic solvents. The company also is adding an alkylation unit at this refinery and expanding its gas-processing facilities.

Other work to be taken up includes expansion of a 3000-barrel-a-day Houdriformer at Sun's Sarnia, Ont., refinery.

Standard Oil Company (Indiana) will build four new office and laboratory buildings on the site of the Hydroformer that was destroyed at its Whiting, Ind., refinery in August 1955.

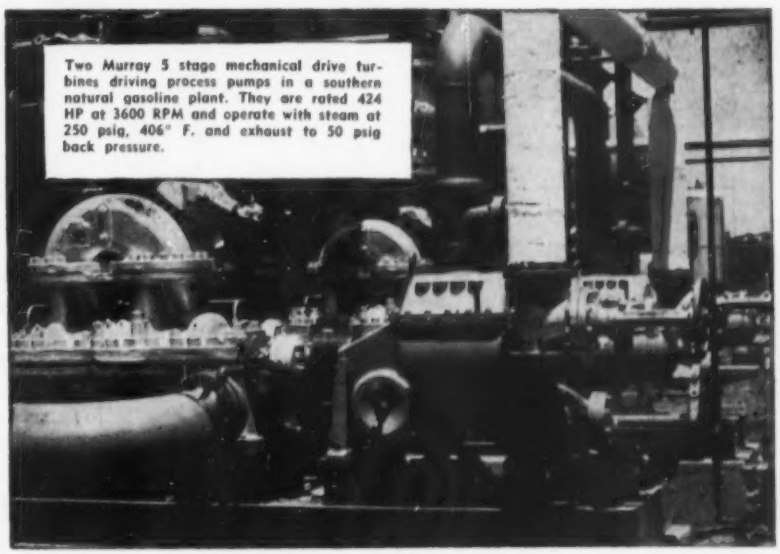
Instead of rebuilding the unit, Standard is stepping up construction of two Ultraformers which had been planned before the fire. The new units will have a combined capacity of 30,000 barrels a day. This is almost 8000 barrels a day more than the capacity of the Hydroformer.

Humble Oil & Refining Company will expand its butadiene plant at Baytown, Texas, increasing production capacity from 49,000 short tons a year to 65,000. Additions to the plant will include one water-wash and three distillation towers, an air-cooled condenser, three settlers, an ammonia compressor and a 3750-KVA electrical substation.

Esso Standard (Near East), Inc., has offered to build a refinery in Syria at its own expense. The proposal, to build a 10,000-barrel-a-day refinery, came as the Syrian government received bids for a projected refinery at Homs.

The Standard proposal has no connection with the projected government plant. If the offer is accepted, however, the government is expected to abandon plans to build its own refinery.

Murray Turbines



Two Murray 5 stage mechanical drive turbines driving process pumps in a southern natural gasoline plant. They are rated 424 HP at 3600 RPM and operate with steam at 250 psig, 406° F. and exhaust to 50 psig back pressure.

● MURRAY TURBINES for mechanical drive can be furnished for various combinations of the following conditions:

Horsepowers up to 15,000
Speeds up to 11,000 RPM
Steam up to 600 psig, 750° F.
Back pressures up to 300 psig., or condensing

● MURRAY mechanical drive turbines are built in various combinations as follows:

Single stage turbines
Multi stage turbines
Mechanical fly ball type governors
Oil pump direct acting oil governors
Oil pump oil relay governors
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Multiple automatic governor controlled inlet valves

MURRAY IRON WORKS COMPANY
BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

For more data on advertised products, use Readers' Service Cards, last page.

Employes are seeking . . .

A Place to Grow

Here is a concise analysis of modern industry's manpower development problem—plus ways to solve it.

William E. Bright, Jr.
Chairman, Committee for Employe Development
The Pure Oil Company, Chicago

IN THE PAST decade few industrial needs have commanded more attention than that of planning for the orderly development of personnel. This has become necessary because of the growing feeling of insignificance on the part of the worker, resulting from the continued growth and mechanization of industry. Now, however, management in many companies has begun to recognize more fully the employe's human needs.

There are three main forms this management recognition has taken. Each derives from a different management philosophy.

In the first, management takes a reluctant, negative approach. It feels it is yielding prerogatives and profits to the employe's unreasonable demand for ever-greater consideration. Such a management seldom gains any increase in productivity for the "prerogatives and profits" it spends. And this, of course, seems to management, to justify its negative point of view.

The second approach is simply modern paternalism. Management graciously yields to the inevitable, hoping thus to buy loyalty at the expense of installing one employe benefit plan after another. Until finally, all of its spineless employes are lethargically "secure," its average employes are "spoiled" and those with enough initiative to become capable managers have all resigned.

Both these approaches to employe relations treat this function of management as an expense. Quite as if maintaining morale were like maintaining equipment. When profits contract so does the employe relations budget.

There is, fortunately, a third alternative. This approach interprets the employe's growing demand for significance in the enterprise as evidence of his desire to earn the increasing satisfactions he seeks. To treat him as part of his machine will breed frustrations that impair his productivity. To give him anything he does not merit will destroy his initiative. To impede his self-development will lessen his potential usefulness to the organization.

What he really wants, this management believes, is to work in an environment that provides maximum opportunity for him to produce and grow. Given this he can in most instances be expected to become continually more useful to both the company and himself.

The third approach, unlike the others, does not identify employe relations as an expense. Instead it becomes a means for improving efficiency, productivity and the supply of replacements for managers at all levels of the organization. When profits fall employe relations is one of the functions management looks to for help in rebuilding them.

Without this third point of view it is futile for a company to go through the motions of personnel development. To do so can only damage the organization. It is both more honest and resultful for such a company to admit that it prefers to live in the 19th Century. Management might much better openly declare it believes in unguided experience, the intuitive selection of managerial personnel, and a primitive form of the "survival of the fittest." Then its young men who believe that the horseless carriage is here to stay may seek a less antiquated environment elsewhere.

What's In A Name? Let us assume now that your company does take the view that planned personnel development will in the long run improve its profits. On the AMA premise that "informal activity" in a function like this is a pleasant synonym for no activity at all, you plan to establish an organized program of personnel development. What should you name the program?

Well, why not "personnel development?" That is what we have been calling it in this article. And it does seem to have descriptive value.

In recent years most companies have avoided the semantic disadvantages of using names like "Management Development" or "Executive

MODERN MANAGEMENT MEETS EMPLOYE NEEDS IN THREE WAYS:

1. ***The reluctant, negative approach.*** **Management feels it is yielding prerogatives and profits to the employes' unreasonable demand for ever greater consideration. Employe relations is considered an expense.**

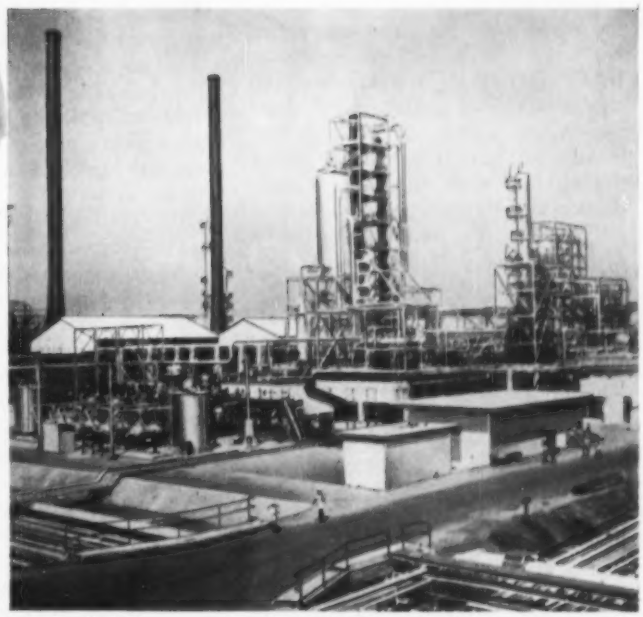
2. ***The paternalistic approach.*** **Management graciously yields to the inevitable, hoping thus to buy loyalty at the expense of installing one employe benefit plan after another. Employe relations is considered an expense.**

3. ***The approach which provides an environment for the employe to produce and grow,*** **with three objectives in mind: To improve efficiency—to increase productivity—and to supply replacements for managers at all levels of the company. Employe relations is *not* considered an expense.**

IN WHICH CATEGORY DOES YOUR COMPANY BELONG?

difficult physical conditions, but...

India's largest refinery was completed a year ahead of schedule



The 40,000 B/D refinery of Burmah-Shell Refineries Ltd. near Bombay, India is the country's largest. It is capable of supplying an estimated half of India's current requirements for finished petroleum. Although built in the face of difficult physical conditions, close cooperation with the owner in planning and engineering, and exceptional coordination of construction allowed Lummus to finish almost a year ahead of the original schedule.

A smoothly running refinery now, consisting primarily of crude distillation, fluid catalytic cracking, gas recovery, treating and blending units, offsite facilities and utilities, at the start it was only 450 acres of incredibly difficult terrain, without roads, railway or harbor.

Battling two of Bombay's worst monsoons, Lummus employed as many as 14,000 Indians at peak periods. Terrain was filled and drained. Roads, rail lines, harbor facilities, and the complete refinery were constructed. The job was kept moving *ahead* of the timetable – and finished 21 months from the start of construction.

A project of this magnitude requires a worldwide organization of experienced engineers and construction men able to cope with any problem. Lummus is such an organization and can design and build your next plant whatever the size, type or location.

The Lummus Company, 385 Madison Avenue, New York 17, New York. *Engineering and Sales Offices:* New York, Houston, Montreal, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Caracas. *Heat Exchanger Plant:* Honesdale, Pennsylvania. *Fabricated Piping Plant:* East Chicago, Indiana.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.

Development." It seems wise to consider all who receive wages as "employes" or "personnel," whatever their echelon. And it is likely the company's owners, themselves, hold this point of view.

But a few companies lately have also shied away from using a name which might imply management feels it can develop—or grow—human beings. Men, like trees, grow more or less of themselves. Hence the name "Organizational Development" is achieving popularity and it has much to recommend it.

Psychological Conditions of Work—There are two ways to get to the top of an oak tree. You can either climb the tree . . . or sit on an acorn. In Organizational Development the choice is limited to the second alternative.

All management can do is create the kind of work environment conducive to self-development and then let nature or the natural motivations of man take over.

If a proper atmosphere or work environment is all we can hope to achieve let us examine its nature. What is this environment that stimulates individual initiative and provides maximum opportunity for its exercise?

George Elton Mayo, in his famous experiments at the Hawthorne Works of the Western Electric Company between 1924 and 1927, demonstrated that a strongly motivating environment does not stem from the physical conditions in which work is performed. He discovered, according to D. C. Miller and W. H. Form in "Industrial Psychology"—"something which increased output no matter what was done about physical conditions."

Mayo started out to test the effect improved physical conditions of work (better lighting, rest breaks, etc.) have upon productivity. His experiments backfired. One group, used just to get a comparison and for whom no "improvements" were made, matched the increased output of the employes whose environment was physically improved.

So Mayo began taking away the physical improvements given to his test group, and—to his surprise—the output kept right on going up.

Since 1927 this experiment has several times been repeated with similar results. By elimination of alternative causes, it has been demonstrated now that the main reason for the improved output in these experiments is psychological.

The test employes felt more important because of being included in the experiment. They felt they were expected to develop improved performance. So this is exactly what they did.

For the first time each test employe felt like "a partner in the business." As if his work were really important. As if management were asking his advice and aid in improving the operations of the company. As if he were "participating" in the management of his own work. It is no longer "surprising" as it was to Mayo in 1927 that productivity improved.

The most significant aspect of the fully motivating work environment is a continually demonstrated desire on management's part to have each employe participate in making the business successful.

Peter Drucker calls it "management by objectives." Others describe it as "participative" or "consultative" management. By whatever name, it involves delegating to each employe every authority and responsibility he is capable of exercising . . . and it takes a very generous view of his capabilities.

Perhaps even more significantly, this kind of managing requires management to have infinite confidence in the good intentions of its employes.

Without respect for the individual merit and confidence in the honest intentions of employes, it is inconceivable that a management could practice consultative managing.

There is another interesting way to view this situation.

Sometimes managers have told me their men are stupid and untrustworthy. In saying this they also tell me what their men think of them.

Companies frequently conduct opinion surveys to discover how employes feel about the company and its management. Such surveys are usually worthwhile for their many indications of specific employe needs. But for the purpose stated—to discover how employes in general feel about their work and management—no elaborate survey is actually required.

All any manager, who wants to find what his men think of the company and of him, has to do is survey his own opinions of his men. When he has set down exactly what he thinks of his men, he has an accurate record before him of what they think of him.

For respect and confidence are reciprocal. If he believes his men are competent, they will respect his judgment as a manager. If he trusts their motives they will have confidence in him. If he underrates their ability and is suspicious of their motives how can they possibly feel any other way about him?

Do you and I trust people who have no confidence in us? Do we respect peoples' judgment when they have a poor opinion of ours?

Literally, whatever the manager's expectations of his men are, they are quite likely to be fulfilled. And this may be extended to the expectations an entire management holds for the whole organization.

The keystone in any program of Organizational (or personnel) Development is an attitude of trust on management's part in the merit and motives of employes that will facilitate "managing by objectives." The kind of managing that encourages maximum participation by the employe in the direction of his own work.

"Everyone Is Queer But Me and Thee"—What are the psychological needs such an environment can hope to satisfy in the individual employe? Why does he work and grow most beneficially in a psychologically satisfying atmosphere?

A group of supervisors attending a session of the Industrial Management Institute at the University of Wisconsin were given a list of 10 things employes want. They were asked to rank them not on personal significance but to indicate their estimated importance to the employes.

Two items on the list of 10 were, of course, "good wages" and "job security." The Wisconsin supervisors said these two items were most important to their employes.

Then they viewed the results of an opinion survey in which 10,000 workers ranked these same 10 items; they also saw how the immediate superiors of these men ranked the items for appeal to workers.

The Wisconsin group and the immediate superiors of the 10,000 work-

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Engineering Recommendations — Barco will be glad to make detailed recommendations to meet your requirements. See your local Barco representative or write for a copy of new Catalog 215B.*

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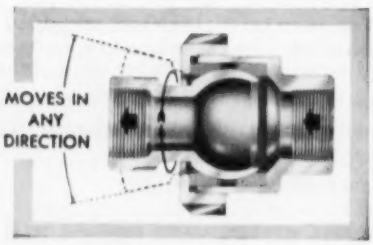

As Management Sees It . . .

ers were in close agreement as to what employes want. Both were in almost complete disagreement with what the 10,000 employes themselves said they wanted.

Do you suppose this convinced the Wisconsin group of supervisors they ought to re-evaluate their understanding of the things their employes want? On the contrary, they insisted the findings of the survey must be wrong. It was called to their attention that most of the many similar surveys made over the years support the ranking the 10,000 workers made.

The group still insisted they were right and all the surveys were wrong.

Someone pointed out that labor union demands—with their stress of higher wages and greater seniority rights—"prove" these are the things employes want most.

Subsequent discussion indicated, however, that the group felt the union does not always accurately represent the wishes of the individual employe, that it has interests separate from his and that the union tends to express employe wants in a politically realistic, socio-economically acceptable form. The union needs a tangible record of accomplishment in its members behalf that it can point to with pride. Hence it sometimes adopts substitute goals.

It became clear that the group did not believe union leaders know what employes want.

You can see what an interesting situation this had become. These conclusions seemed inescapable:

- Employes *do not* know what they want.
- Unions *do not* know what employes want.
- Supervisors *do* know what employes want.

Even when these conclusions had been stated many of the supervisors held to their original conviction. Another evidence of how futile logic is when applied to an emotional situation. But, of course, these foremen were also misapplying logic themselves.

A Need Provides Motive Power— A consistent pattern of employe wants or needs has emerged from the dozens of competent surveys now available from universities, trade and industry associations and consulting organiza-

Announcing

TWO GREAT EVENTS FOR MAY 17TH

THE CONSOLIDATION OF THREE GREAT COMPANIES

The Key Company, W-K-M Manufacturing Company, Inc., and ACF Valve Division—all members of the ACF Industrial Family—have been brought together as W-K-M Manufacturing Company, a subsidiary of ACF Industries, Inc.

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OPENING OF A GREAT NEW PLANT THURSDAY, MAY 17TH TWO to SEVEN P. M.

You are cordially invited to inspect our new Plant and Office at Missouri City, Texas, just a few miles west of Houston.

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"Then, what did they say?"

"The engineers agreed immediately. Then we went over the details of this proposal and engineering data Pritchard submitted on our new off-site facilities."

"Our engineers are a pretty hard group to sell. What made them agree with you that Pritchard is qualified for this job?"

"Two things. First, they are familiar with other off-site jobs Pritchard has done. Second, we've worked with them before. Remember how smoothly that last refinery job went? Complete teamwork and cooperation between our personnel and theirs. That was a Pritchard job."

"Yes, I remember. You know it takes an organization with plenty of experience and know-how to tackle an off-site job like ours."

"You mean an outfit like Pritchard!"

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As Management Sees It . . .

tions. If a company—or a manager—is aware of this pattern of human needs in an industrial setting it can work wonders in motivating its men to improved performance and realization of latent abilities.

In a recent talk before an industrial group in Chicago Dr. C. H. Lawshe of Purdue University identified the needs that constitute the supervisor's motive power. His list is brief:

- The need for personal economic security.
- Opportunity for expression of individuality (including growth).

Dr. Lawshe then pointed out that the need for personal and economic security can be oversatisfied as well as unfulfilled. The most productive work environment is one in which a happy medium of "psychologically adequate" security exists. He describes this as one in which:

- Wages and physical working conditions compare reasonably with national and local standards.
- The employe is recognized as a unique individual.
- He understands his duties, company policies, significant changes that affect him and how he is progressing on his job.
- Discipline is loose but clearly defined; firm but not restrictive.

The degree to which a work environment satisfies the employe's need of an opportunity for self-expression can be described in terms of the psychological state the environment creates in the employe:

- Dependency, in which he is a kind of zombie.
- Reactive independence, in which he is frustrated and works against the company's interests.
- Creative independence, in which the employe identifies his own interests with those of the company and achieves maximum productivity and growth.

Looking at this from another perspective the work environment that is most stimulating to productivity and individual self-development is characterized by three major components:

- Participation of the employe in the management of his own work.
- Delegation of responsibility that is proportioned to each individual's emotional maturity and work experience.
- The opportunity to benefit from making mistakes.

So we have returned to the emphasis placed upon management attitudes and policies in the first paragraphs of this article.

Since management cannot effectively "command" employes to improve their productivity or self-development, the only alternative is for management to achieve a work environment that fosters these essentials to the company's success. Helping management to achieve the environment we have used excerpts from Dr. Lawshe's remarks to describe, is the goal of the personnel or organizational development program.

How Is This Environment Achieved? Such an environment, of course, is not achieved through formal traning programs. Rather it stems from management's philosophy of operation, from company policies that express this philosophy and—even more significantly—from the example top management sets in its relations with middle management.

For actions still do speak louder than words and a subordinate determines his own behavior by analyzing the way his superiors handle their affairs—and him.

Whatever the specific projects that comprise an Organizational Development program, they are significant largely as tangible evidence of the management's interest in creating a work environment that promotes productivity and provides maximum opportunity—and rewards—for self-development of employes at every echelon of the organization.

There must be a firm conviction that the employe relations functions is not an expense. A belief, instead, that a sound personnel development program is today's most effective medium for improving the long-term profits of the enterprise. The company must realize that its most precious assets exist in the minds of its men. Their ideas, support and growth will determine the period and degree of the company's continuing success.

AUTHOR'S NOTE

Views and ideas contained in this article are based on the author's outside experience as well as upon his regular job but do not necessarily represent the stand of The Pure Oil Co. on the topics discussed.

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How Do Your Supervisors Rate?

Here are some new ways in which a merit rating system can be used to evaluate foremen and job performance. Check yourself on the self-analysis chart.

Robley D. Stevens
Management Consultant, Washington, D. C.

A SYSTEMATIC merit rating program will provide your management with the information necessary to gain the highest supervisory quality and performance. Any merit rating program, of course, is not a substitute for intelligent and enlightened personnel relations, but it may be applied in a practical way to help your supervisors improve their efficiency.

It is vital that the skills and abilities of all employes be fully utilized. The burden of effecting this falls squarely on management. If your supervisors are inefficient, full utilization of your workers is licked from the start. And, of course, the increase in your turnover rates resulting from competition for skilled workers can be minimized by providing supervision of high quality.

Good supervisory selection and rating is important to every company, but if it is not supported by good supervisory training, it can substantially nullify your program. However, giving supervisory rating to those who lack the personal qualities and abilities needed by supervisors is like watering a garden where nothing has been planted.

All companies—large and small—are concerned with cost. An improperly trained and rated supervisor can be costly. This fact has been increasingly appreciated by employers in our American free enterprise system. It's a rare thing now to find an organization which considers its supervisory positions in the light of rewards for dogged, faithful service. A systematic, purposeful approach to filling supervisory jobs seems to be the rule today.

In brief, the approach implies three steps:

- **A thorough study of the particular supervisory jobs involved.**
- **Determination of the characteristics of individuals which best meet the needs of the jobs.**
- **Establishment of a valid and practical way to find out which individuals have these characteristics to the most desirable degree.**

Supervisory rating programs which fulfill these requirements pay dividends. Actually they will turn up supervisory talent which otherwise would never have been recognized. Even in a small oil company persons with good supervisory potentials are overlooked. In large firms the risk of this is substantially magnified. And, the program will spotlight talent obscured by one or another of the above factors.

Experts in management will tell you that a merit rating program for supervisory personnel is a sort of insurance policy against the appointment of persons who just can't make the grade as supervisors.

Also, the program bolsters workers' morale in two ways:

The knowledge that a definite merit rating program is in effect relieves the anxiety of workers that they may not get the recognition they might merit and that others, less worthy, may get preferment. And it salves the wounds of workers disappointed in their expectations of a promotion to know that their abilities were considered, that they didn't lose out because somebody "had it in for them," and they can try again for the next supervisory opening.

A merit rating program for supervisory personnel speeds up the process of filling vacancies by an advance evaluation of persons who are eligible so that all the preliminary work is finished and available when a selection must be made. This realization has resulted in a more careful selection of supervisors.

Recent studies by management experts generally indicate that today oil companies look for the following qualifications in supervisory personnel: Leadership ability, organizing ability, character, judgment, technical skill and mechanical ability, education, initiative, human interest and physical and mental requirements.

Many companies generally try to find people within their own organization who can be promoted to the position of supervisor whenever a vacancy occurs. They seem to do this because it has a definite bearing on the growth and development of super-

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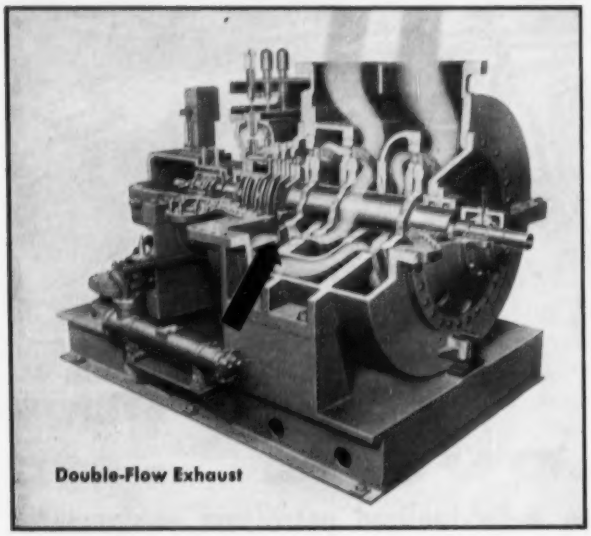

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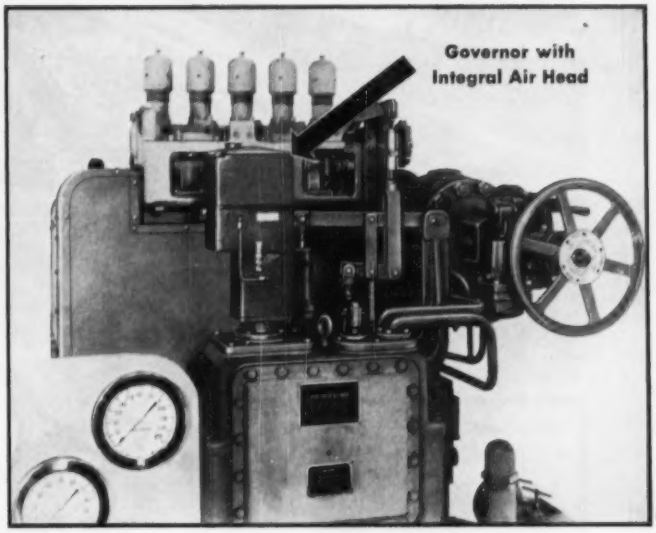

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Compressor-drive turbine installations up to 12,000 rpm, and 24,000 hp, show Worthington leads in application engineering, design, reliability.

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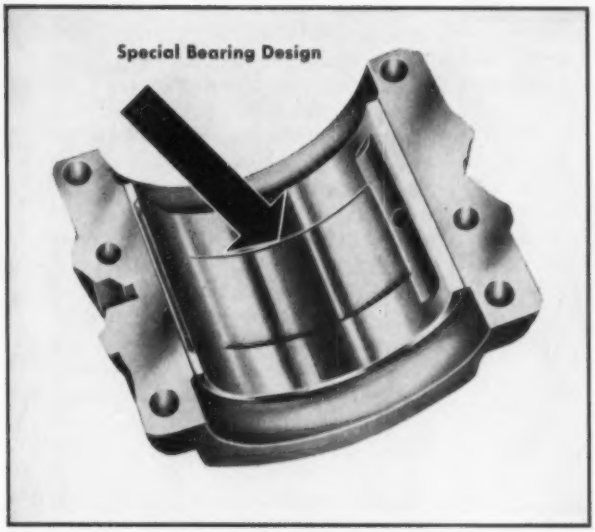

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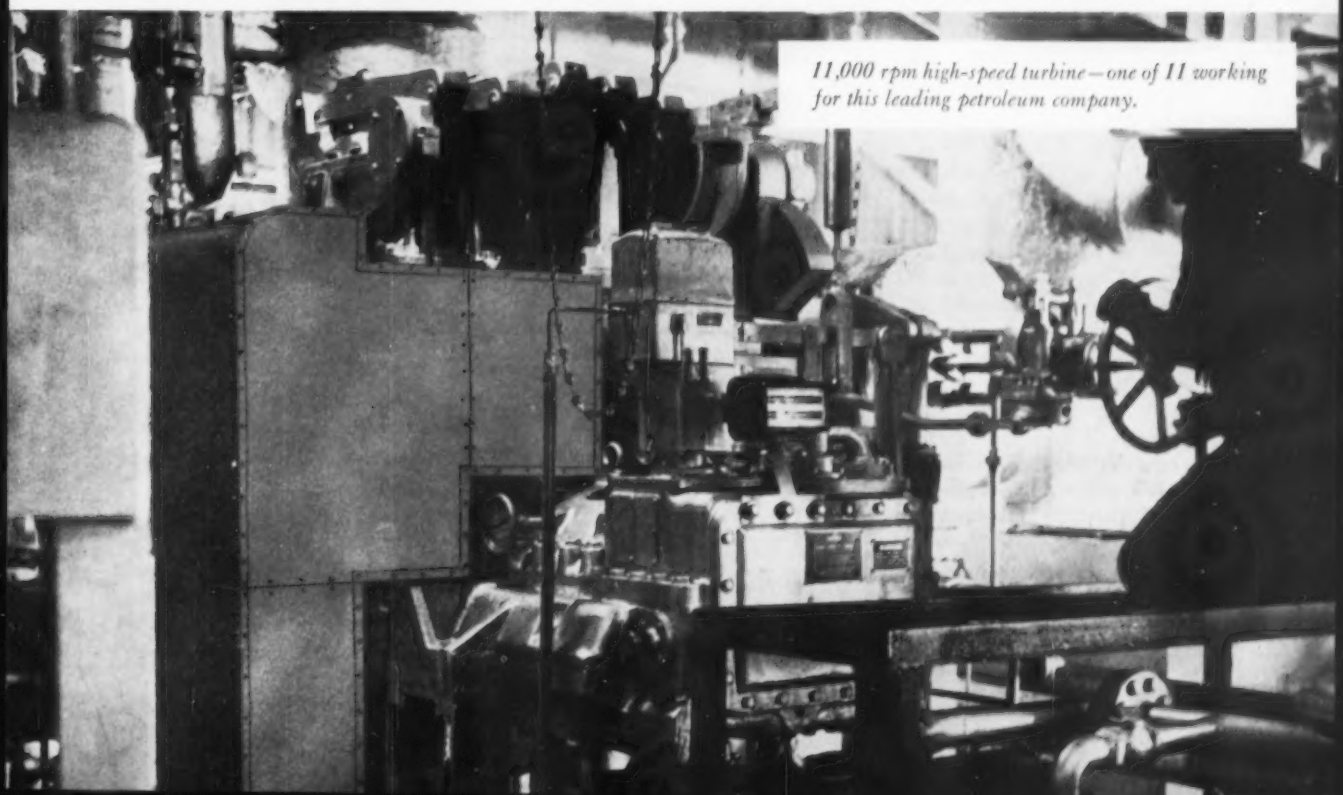
Automatic Nozzle Control	Cam operated—for economy and better control.	✓			
Governor	Has integral air motor—for more accurate control.	✓			
Type Construction	Double flow exhaust for economy and long life.	✓			
Packing	Labyrinth—for most effective seal at high speed.	✓			
Test	Load test—to be sure you get what you ordered.	✓			

LOWER MAINTENANCE COST. One important example of construction used to help eliminate non-scheduled maintenance is Worthington's anti oil-whip bearing. During operation a pocket (arrow) in the upper half of the bearing builds up a pressure pad of oil. High pressure here creates a downward force on the journal, holding it in place in the bearing, preventing destructive vibration.

LONGER LIFE. A long, trouble-free life can be attributed to no *one* turbine feature, but rather a combination of many engineering advances. Compare design features yourself, one by one. Far ahead of any other manufacturer in the compressor-drive field, Worthington's first compressor-drive turbine built in 1927 is still working around the clock, in a large Eastern gas plant.



11,000 rpm high-speed turbine—one of 11 working for this leading petroleum company.

visors. More and more skilled workers are looking for jobs that offer career opportunities, and as long as an oil company holds to the policy of promotion from within, workers feel that their present company offers career possibilities.

The first step in any merit rating supervisory program should be a job analysis. Yet in the analogous situation of selection and rating of supervisors, there is a great temptation to try to fill the job without knowing anything more than that a supervisor is wanted. It is true that all supervisory jobs have some common elements, but it is important to recognize that no two supervisory jobs are identical and that, in some cases, the differences are as important as the similarities.

In the most inclusive possible terms the job of every oil company supervisor is to get out production. A correlated objective is that of seeing that his subordinates obtain job satisfaction. The supervisory job consists of a multitude of duties subordinate to these fundamental ones. But even more than that, the supervisor in every company is responsible, too, for interpreting management policies and programs to the subordinates and for giving these policies and programs his full support.

In addition, supervisors are the worker's "pipe line" into management. Workers' suggestions and complaints that fall to management are usually transmitted through the supervisor. And, of course, the supervisor has the clear responsibility of setting a good example to his subordinates in his own work conduct, attitudes, and actions. He must act in such a way as to improve morale and decrease friction among the subordinates. Hence, when a supervisor in your company is "improving morale," he is really improving his performance in one of the basic supervisory duties.

Management will find that there are differences between supervisory jobs which are based on the weakness or strength of the previous incumbent. The job of the newly selected and properly rated supervisor of a unit formerly piloted by a whip-cracking martinet is going to be a very different proposition from that of a supervisor taking over from an amiable incompetent.

The supervisor of women has a different job from that of the supervisor of men. In motivating his subordinates, the supervisor must select the motivation that is most likely to be important to each worker.

It is recognized that the job of supervising generally operates most effectively when the supervisor devotes full time to this primary duty—supervision. In short, everything that an oil company supervisor does is an act of leadership. He leads by setting a good example. As long as supervisory positions exist, men must be selected and rated to fill them.

The necessity of job analysis and the primary characteristics that are required for most supervisory jobs have been described. The next question is: What formula to use in determining the needed skills of a supervisor? The answer to this would appear to be a statement of minimum qualifications as being highly important. Job analysis is extremely important in setting minimum qualifications. However, by careful delineation of the background and characteristics needed for a particular supervisory position, management can eliminate many undesirable persons.

A systematic supervisory selection and merit rating program is no panacea. Your management may be convinced of the need for it because of the large and expanding needs for competent supervisors, because of the greater effectiveness of such a program, or because of its morale advantages. To what positions and at what level should this program be applied depends upon your management. The program can be carried on formally or informally and administered by the personnel officer.

Meet the Author

ROBLEY D. STEVENS is a Washington correspondent and management consultant specializing in public-labor-personnel relations. He is a former representative of the Labor Department and was connected with the Army and Navy departments in civilian capacities. He is author of two books on labor relations as well as a number of magazine articles in that field. Stevens holds both LL.B. and LL.D. degrees from Blackstone School of Law.

Supervisor's Self-Analysis Chart

How Do You Measure Up?

1. Understanding My Organization:

Do you know the functions of your department and how they contribute to the total policy of your company?

Yes ☐ No ☐

Do you show each worker how his job fits into the over-all picture?

Yes ☐ No ☐

Can you determine lines of authority and responsibility?

Yes ☐ No ☐

Can you determine number and type of workers required in your department?

Yes ☐ No ☐

Can you make logical duty assignments based on clear outline of responsibility and authority?

Yes ☐ No ☐

2. Getting the Work Out:

Do you give directions that are clear, understandable,

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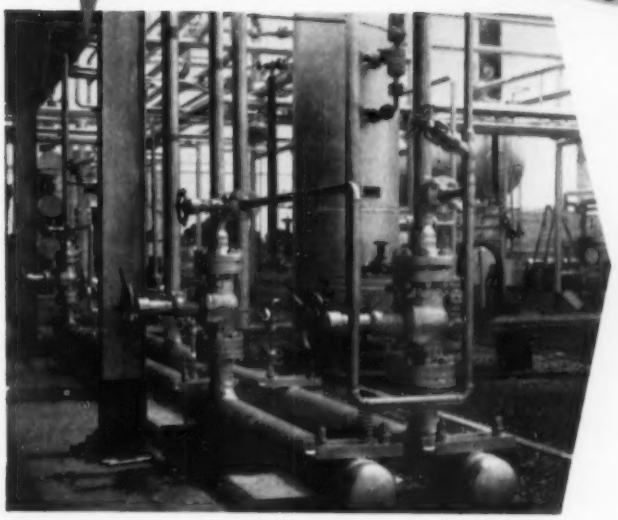

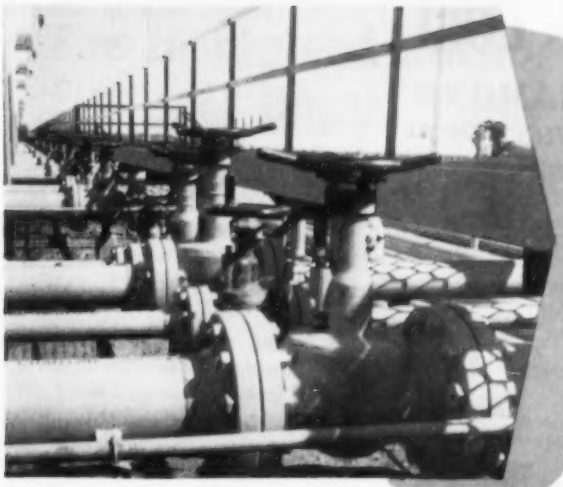

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Other products: A.W. ALGRIP Abrasive Rolled Steel Floor Plate—Plates—Sheets—Strip—(Alloy and Special Grades)

For plants where oil, water and grease raise special problems of slipping accidents, we suggest a check on the special qualities of A.W. Algrip . . . the world's only abrasive rolled steel flooring.

and specific?
Yes ☐ No ☐

Do you review work for progress in meeting schedules?
Yes ☐ No ☐

Do you know how to coordinate the work of your department and take action as necessary?
Yes ☐ No ☐

Do you see that your workers do what is rightfully expected of them?
Yes ☐ No ☐

Do you constantly emphasize the control of cost?
Yes ☐ No ☐

Do you minimize the necessity of overtime work?
Yes ☐ No ☐

Do you resolve your production problems immediately?
Yes ☐ No ☐

3. Planning and Scheduling Work:

Do you keep up with the workload of your department?
Yes ☐ No ☐

Do you plan priorities of work and schedule accordingly?
Yes ☐ No ☐

Do you always plan for the best use of manpower, space, and equipment?
Yes ☐ No ☐

Do you establish realistic goals for your workers?
Yes ☐ No ☐

Have your workers participated in setting their own goals?
Yes ☐ No ☐

Do you plan to meet deadlines and emergencies?
Yes ☐ No ☐

4. Improving Working Methods:

Do you analyze operations of your department as a whole?
Yes ☐ No ☐

Do you evaluate present methods of performing jobs?
Yes ☐ No ☐

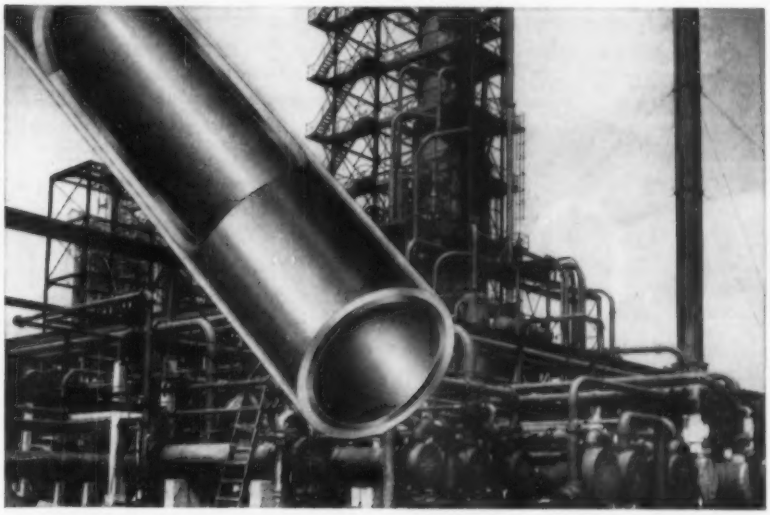
Continued on Page 284

BRIDGEPORT BRASS COMPANY

CONDENSER AND HEAT EXCHANGER TUBE EDITION

COPPER ALLOY BULLETIN

Bridgeport Brass Co. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL



The Inside and Outside Story of Duplex Tube

In cases where a different type of corrosion attacks each side of a heat exchanger tube, many users of heat exchanger tubes have found that tubes made of a single metal often are not a solution to both corrosion problems. This is the reason why Bridgeport Duplex Tubes were developed—*because a one-metal tube had not proved itself the universal answer to dual corrosion.*

Bridgeport Duplex Tubes are supplied in more than 100 combinations of ferrous and nonferrous metals. Their economy has been clearly proved. If your heat exchanger tubes are failing to give you all the service life you think you should get, it is very likely that Duplex Tube—which takes advantage of the best qualities of *both* metals—can save you money. Our specialists will be glad to study your problems, and assist in selecting a combination of tube that best fits your needs.

Installation of Duplex Tube is not suggested as the solution to *every* tube problem. But where dual corrosion conditions exist, Duplex Tubes can save money. Before we recommend Duplex Tube, each alloy is carefully selected to withstand the specific corrosion problem on each side of the tube. Pitting or cracking—faults frequently found in certain types of one-metal Tubes—is often eliminated by Duplex Tubes. By gauging the thickness of inside and outside tube walls to the rate of corrosion, longer and uniform tube operating life are assured.

Heat transfer properties of Duplex are often actually better than those of single-wall Tube. This is a result of Bridgeport's method of manufacture which insures a good, tight mechanical bond between the two alloys. The table illustrates why smaller or more efficient heat exchangers are possible with Duplex Tube.

RESULTS OF HEAT TRANSFER TESTS DUPLEX VS. SINGLE WALL TUBE

Steam Condensed on Outside Surface With Fresh Water Passing Through The Tubes

Water Velocity Feet per Second	OVERALL HEAT TRANSFER RATE AT INDICATED WATER VELOCITY BTU/HR./SQ. FT./° F.	
	Duplex Tube ¾" O.D. x Wall Thicknesses .0325" and .0325"	Regular Tube ¾" O.D. x Wall Thicknesses .065"
	Steel to Steel	Steel
2½	371	380
3½	458	458
	Copper to Copper	Copper
2½	580	600
3½	750	740
	Steel to Copper	Steel
2½	465	380
3½	625	458

Heat exchanger tubes that do not give full service life cannot give their operators their money's worth. The service that tubes will give should be balanced by the costs of maintenance, retubing and, of course, the original cost of the tubes. Here, as an example, is the experience of one oil refiner. His first heat exchanger tubes of Low Carbon Steel had lasted only 4 to 5 weeks, and each retubing job cost him more than the tube itself. He then replaced the Low Carbon Steel with another more highly resistant tube, and operating life increased to 3 months. Still not satisfied that he was getting maximum service life for his investment he installed Duplex Tube, stainless steel to the product side and a copper alloy to the cooling side. That was *two years ago*, and his Duplex Tubes are still giving excellent service.

For chemical plants producing colorless formaldehyde, we have supplied Duplex Tubes with Admiralty on one side for brackish water, and aluminum on the outside. For oil refining and natural gas refining, we have made Duplex Tube with steel outside to resist various corrosive vapors, gases and oils; and copper or copper-base alloys inside toward fresh or salt water.

Such experiences with Duplex Tubes have been successful for many years in oil refining, production of synthetic rubber, process industries, chemical plants, coke by-product plants, ammonia production and ammonia refrigeration systems, and other applications. Duplex Tubes have proved repeatedly to be the least expensive equipment over long periods of time because of longer service life and a reduction in frequency of retubing and shut-down periods.

Write today for your copy of Bridgeport Technical Bulletin #1954, describing properties, applications, installation methods and other important Duplex Tube information. (660)

For more data on advertised products, use Readers' Service Cards, last page.

As Management Sees It . . .

Do you develop and apply improved methods?
Yes ☐ No ☐
Do you encourage and assist workers in submitting their ideas?
Yes ☐ No ☐

5. Determining Performance Requirements:
Can you determine what is expected of each worker?
Yes ☐ No ☐

Do you discuss tentative requirements with each worker concerned?
Yes ☐ No ☐

Can you make final determinations of requirements based on needs of management, supervisory experience, and workers' suggestions?
Yes ☐ No ☐

Can you evaluate objectively each worker's performance based on requirements?
Yes ☐ No ☐

ARCCO
NEW
ARCCO-ANUBIS
Laboratory
GAS
BALANCE
SMALL SAMPLE—WIDE SPECIFIC GRAVITY RANGE
No manometer, vacuum pump, air drier or other complex accessories required
This instrument is identical in principle to the well known ARCCO-ANUBIS recording type dry air gas gravitometer. For laboratory use only, this beautiful instrument is ideal for testing samples brought in from the field. Unusually small gas sample is required.
Handles specific gravity range from .5 to 1.5 and by the use of weights a total range from .0 to 2.5.
AMERICAN
RECORDING CHART CO.
3113 E. 11th St. • Los Angeles 23, Calif.
SEND FOR CATALOG No. 101R
ARCCO-ANUBIS
Gas Gravity Instruments
SEND FOR BULLETIN 101-R3

6. Developing Workers:
Can you select the right person for the job?
Yes ☐ No ☐

Do you help workers make adjustments on new jobs?
Yes ☐ No ☐

Can you determine training needs of workers and suggest training by management?
Yes ☐ No ☐

Do you measure results of training in terms of production cost and improved skills, attitudes, and other factors?
Yes ☐ No ☐

Do you discuss career opportunities with workers?
Yes ☐ No ☐

Have you developed an understudy?
Yes ☐ No ☐

7. Maintaining a Cooperative Workforce:
Do you see that workers are rewarded for jobs well done in the company's interest?
Yes ☐ No ☐

Do you commend the entire group on performance when deserved?
Yes ☐ No ☐

Do you transfer and reassign workers for the best use of their abilities?
Yes ☐ No ☐

Have you earned the worker's confidence and loyalty?
Yes ☐ No ☐

Can you adjust differences fairly and objectively?
Yes ☐ No ☐

Do you keep the workers well informed on management policies?
Yes ☐ No ☐

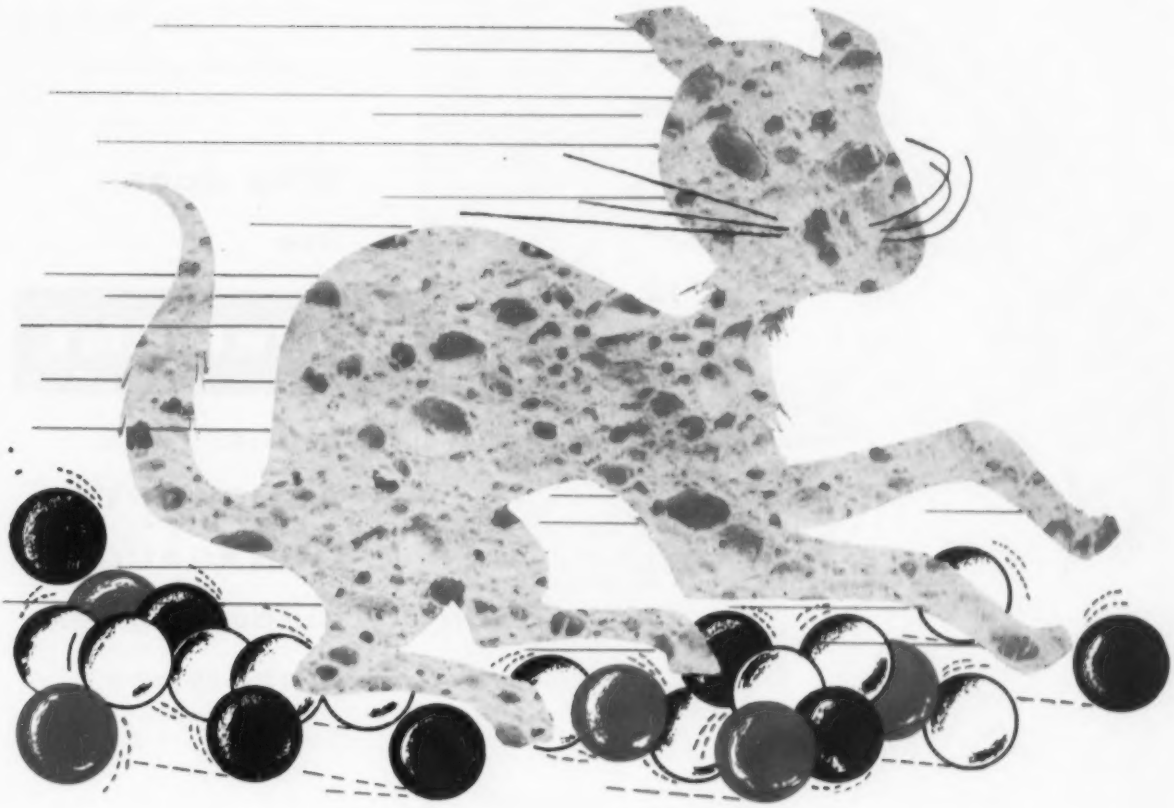
Do you develop and maintain effective discipline among your workers?
Yes ☐ No ☐

Can you initiate corrective and penalty actions as needed?
Yes ☐ No ☐

Do you help to insure safety and welfare of the working force?
Yes ☐ No ☐

Continued on Page 287

For more data on advertised products, use Readers' Service Cards, last page.



SPHERICITY SPEEDS FLOW, REDUCES ATTRITION OF

balanced HI PV* Aerocat® Catalysts

Circulation improves and stack losses drop when catalyst particles are free of snags and corners that impede flow and break off to make fines.

Good sphericity is characteristic of Cyanamid's AEROCAT Catalysts. Balanced with particle size distribution and hardness, sphericity boosts efficiency of catalytic cracking. And to provide exceptional thermal and steam stability, high pore volume is carefully adjusted with pore diameter and specific surface.

Results in cat cracking unit performance are attested by extensive commercial experience, which your Cyanamid representative will be glad to review with you. Ask him today about AEROCAT, and the importance of a *balanced* HI PV catalyst.

CYANAMID

AMERICAN CYANAMID COMPANY
REFINERY CHEMICALS DEPARTMENT
30 Rockefeller Plaza, New York 20, N.Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

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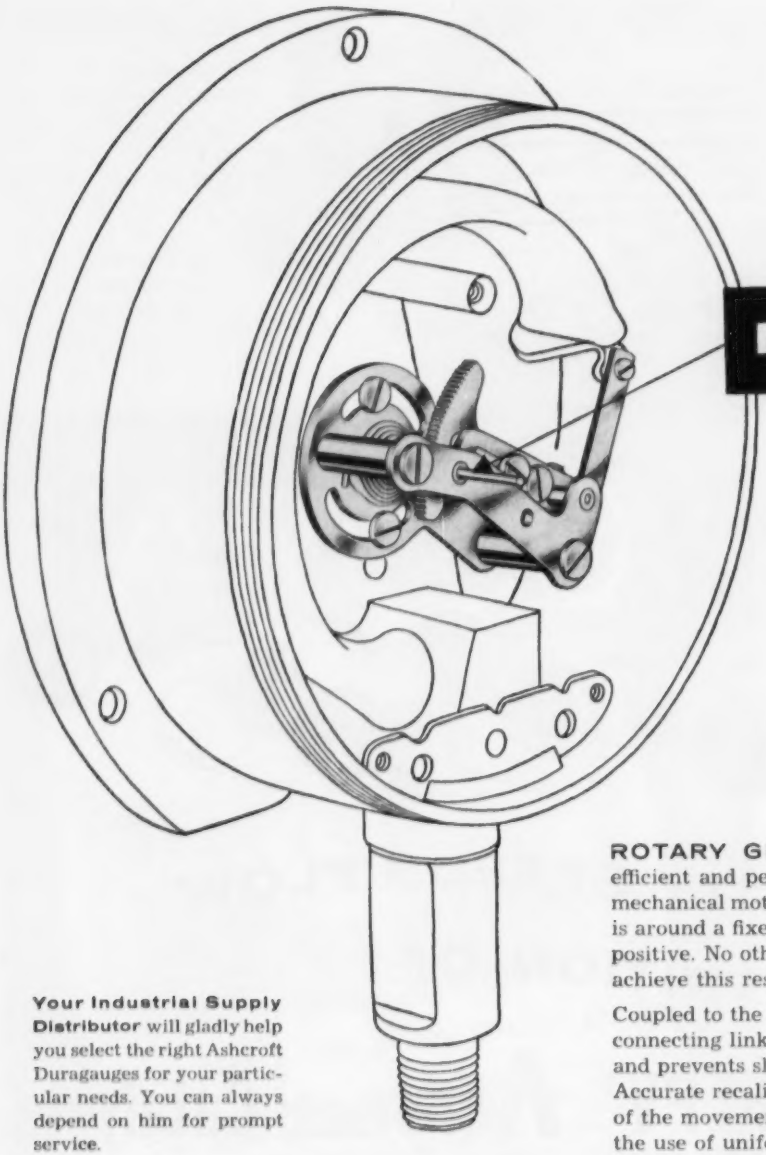


Why does the MOVEMENT in the ASHCROFT DURAGAUGE outperform all other types?

ROTARY GEARED MOTION, the most efficient and perfect method of transmitting mechanical motion ever developed. Because rotation is around a fixed center, pointer position is always positive. No other type of movement can ever achieve this result.

Coupled to the movement is a one-piece connecting link that guarantees correct calibration and prevents slippage or parting under tension. Accurate recalibration is easy from front or rear of the movement. Universal adjustability permits the use of uniformly graduated dials, thereby facilitating maintenance.

The Ashcroft Duragauge is available with all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. There are case designs and materials, Bourdon tube materials, pressure ranges and dial sizes to meet your service conditions exactly. Save time, trouble and money. Specify the pressure gauges of highest sustained accuracy and durability – Ashcroft Duragauges.

Your Industrial Supply Distributor will gladly help you select the right Ashcroft Duragauges for your particular needs. You can always depend on him for prompt service.

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*

ASHCROFT GAUGES

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

As Management Sees It . . .

8. Self-Improvement:

Do you recognize your shortcomings?

Yes ☐ No ☐

Do you constantly improve your ability to get along with people?

Yes ☐ No ☐

Do you develop a cooperative relationship with your superiors, and other personnel above you?

Yes ☐ No ☐

Have you developed a good attitude toward your job and your company?

Yes ☐ No ☐

9. Miscellaneous:

Are you friendly, reserved or antagonistic toward your associates?

Yes ☐ No ☐

Are you highly cooperative, work hard, or non-cooperative in your job?

Yes ☐ No ☐

Do you respond positively, find fault or seek favors?

Yes ☐ No ☐

Do you adjust adequately to changes in duties or working conditions?

Yes ☐ No ☐

Do you keep abreast with latest developments, show initiative in making self-improvement, or are you shy and non-aggressive?

Yes ☐ No ☐

Do your subordinates like you personally?

Yes ☐ No ☐

Do you need more supervisory training?

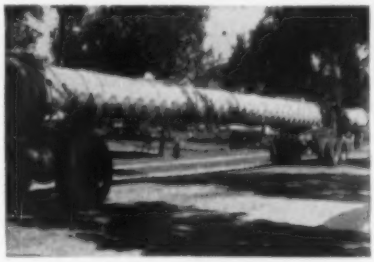
Yes ☐ No ☐

Do you accept, seek, avoid, or dislike responsibility?

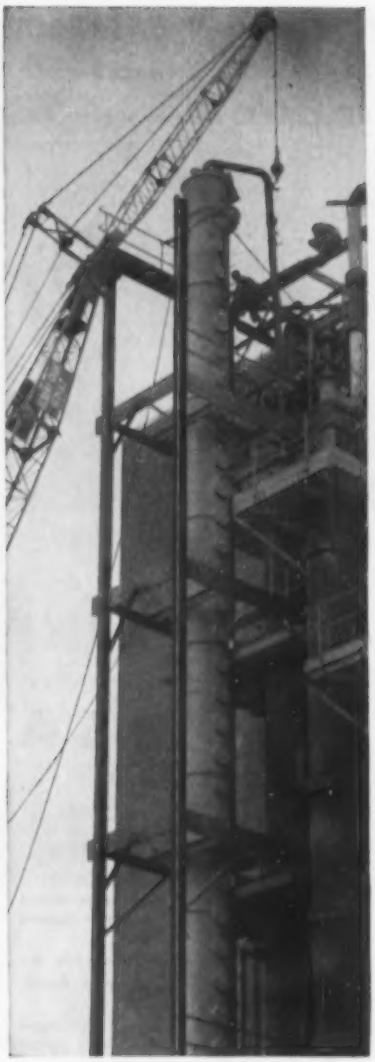
Yes ☐ No ☐

If you answered "yes" to 25 of the questions, you are working together with others for more management power. In so doing you will manage your resources to get better results for your employer. ##

Line-up was checked with transit to hold close tolerances during welding. Tower passed rigid inspections, was Code stamped.



Motor freight saved time and cost.



Field erection went smoothly.

80-tray tower...by Downingtown

Complete mechanical design and fabrication by Downingtown Iron Works. 80 trays welded in shell. Tray flatness held to unusually close tolerance. Ten-inch handhole at each tray. Customer more than satisfied with performance of tower. Send now for Bulletin PF. See what we've done for others...learn what we can do for you on towers, pressure vessels, process equipment.

Diameter: 36″

Total Height: 92′ 6″

Shell Thickness: ⅝″, ½″ and ⅜″

Material: Carbon steel

80 trays, 45 bubble caps per tray

Downingtown Iron Works, Inc.

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION

151 Wallace Ave., Downingtown, Pennsylvania—Branch Offices:

1435 S. 66th St., Milwaukee 14 • 52 Vanderbilt Avenue, Room 2014, New York 17
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DOWNINGTOWN IRON WORKS — Hackney

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

This OPENING and CLOSING motion....

LUBRICATES
your plug valves
AUTOMATICALLY
when you equip with....
DELTA
AUTOMATIC
PLUG VALVE
LUBRICATOR

Engineers agree that plug valves should be lubricated each time they are opened and closed.

NOW they can be—automatically—by the adaption of this simple, fool-proof device, that never forgets.

Each time the valve is opened and closed a measured amount of lubricant is forced in. The reservoir holds enough lubricant for the valve to be opened 50 to 80 times, and is refilled in seconds with the Delta Gun.

The savings in time, trouble and valves will repay the small cost of this Delta Lubricator again and again. Write for details and prices.

The Only Complete Plug Valve Lubrication Company
DELTA ENGINEERING SALES CO.
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DELTA-DESCO
PLUG VALVE LUBRICANTS AND EQUIPMENT

LUBRICANTS FITTINGS GUNS LUBRICATORS

How to Handle Employe Grievances

You can't miss if you use this simple three-step approach in handling employe complaints.

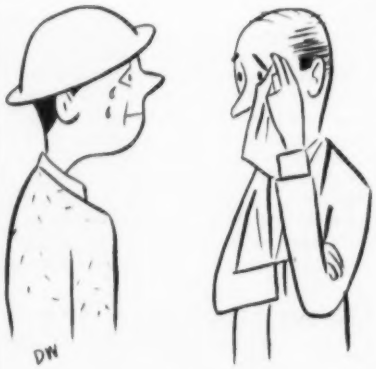
Jack E. Bedford
Armstrong College, Berkeley, Calif.

REFINERY MANAGEMENT'S job would be a great deal easier if there were no employe grievances. On the other hand, management work might be a little boring, too. Every time an employe has a complaint or grievance, either voiced or concealed, there is a human relations problem that management must solve satisfactorily.

Even with a strong union in the refinery and with detailed procedure for handling grievances, there are still a thousand and one little things that can and do happen to bring about a seemingly minor complaint not covered by union procedure. These "seemingly" petty complaints and gripes can fester into serious sore spots and cause considerable trouble.

Here is a simple method that will take a lot of grief out of grievances: CRY, LISTEN and SMILE.

CRY



When an employe in a refinery has a complaint, it is a personal problem with him. Regardless of how trivial it may seem to anyone else, the employe is most sincere about his grievance. It is his complaint and he wants action—immediate and personal action.

One way to get the employe's viewpoint on his problem is to sympathize with him. To stretch a point—cry over his problem. This makes the employe feel that he has at last found a friend. (Lack of friendship, according to industrial psychologists, is one of the major hidden reasons for an employe's complaints.)

Employes with a grievance are not too sure of themselves. Some tend to have a chip on their shoulder and will assume an antagonistic attitude at the slightest provocation. Approaching the employe's grievance

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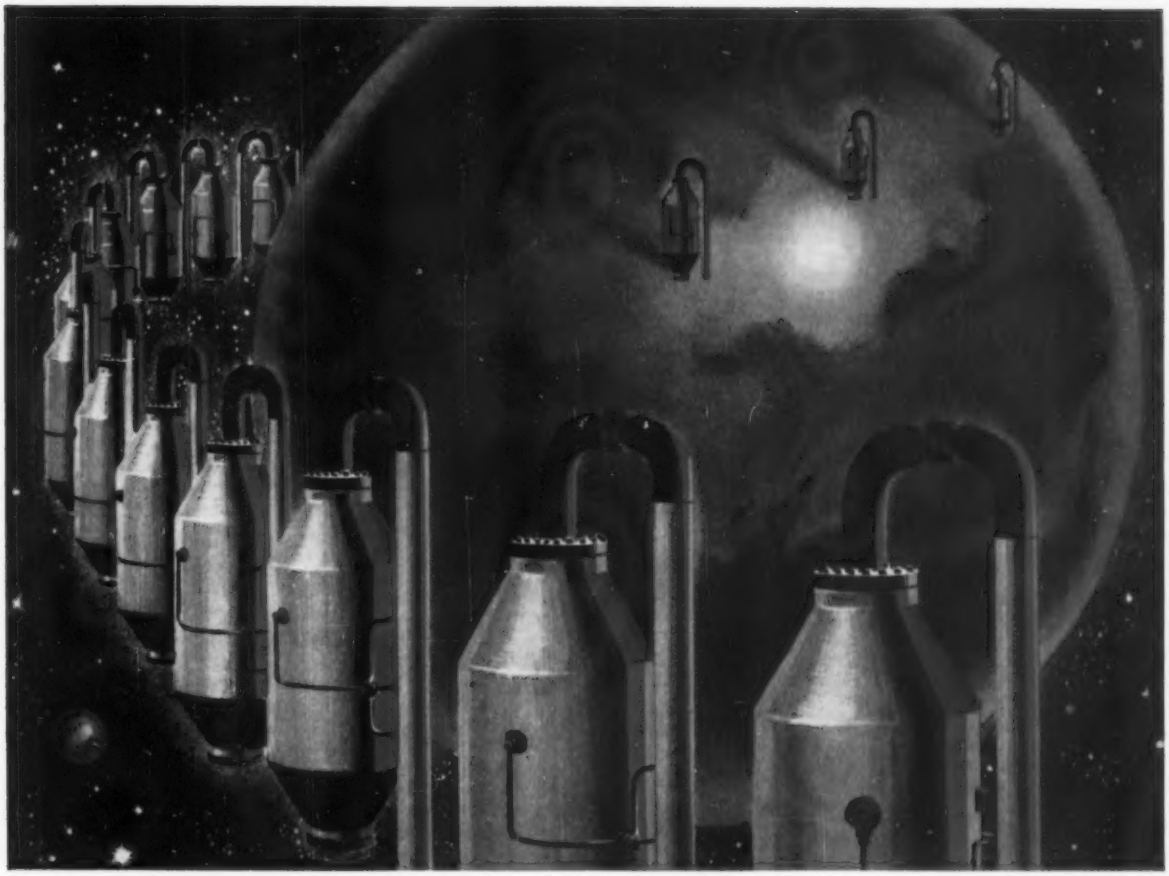

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HIGH OCTANES, HIGH YIELDS AT LOW COST!

Today, well into its third year of commercial operation, Atlantic's Catalytic Reforming Process is proving its ability to give superior results on a broad variety of feed stocks.

Catforming's simplicity brings savings through increased efficiency every step of the way—actually cutting out many intermediate steps.

Regardless of the size of your operation or the nature of your charge stock, Catforming merits your attention. One reason Catforming has "proved out" commercially is Atlantic's broad experience in all phases of petroleum refining.

Phone or write for our detailed brochure, "CATFORMING." The Atlantic Refining Company, Research and Development Dept., P. O. Box 8138, Philadelphia 1, Pa.

it's the CATALYST that counts

ATLANTIC

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ONE OF THE GARLOCK 2,000

...WITH GARLOCK 662 GASKET MATERIAL...

cuts easily, and gaskets will not change shape or shrink in storage under varying climatic conditions. Made from a cork paper base impregnated with a synthetic rubber, style No. 662 resists gasoline, oil and water . . . withstands temperatures up to 300° F. It's ideal for cutting emergency gaskets that you can depend upon. GARLOCK 662 is approved by Underwriters' Laboratories, Inc., for use against hazardous liquids, such as gasoline, naphtha, benzine, fuel oils, etc.

And, longer-lasting 662 Gasket material is only one of "the GARLOCK 2,000" . . . two thousand different styles of gaskets, packings, and seals to meet all your needs . . . The *only* complete line available. That's why you get *unbiased* recommendations from your GARLOCK representative. Call him today, or write for Bulletin AD 146.

THE GARLOCK PACKING COMPANY,
Palmyra, New York

For Prompt Service, contact one of the 30 sales offices and warehouses throughout the U. S. and Canada.

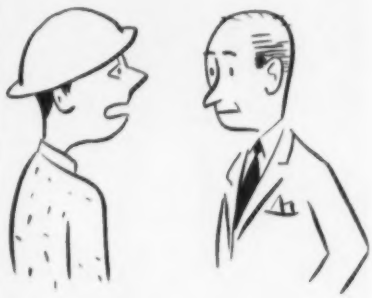
GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

As Management Sees It . . .

with a sympathetic ear will ease the tension.

Then, too, an employe who has found a friendly ear will talk more freely. As the employe talks to a friend he will get down to the true cause of his complaint. This makes it easy to follow the second step of the grievance handling formula . . .



LISTEN

By encouraging discussion it is possible to arrive at the "real" cause of the complaint, determine a solution to the problem, and to develop a plan for presenting the solution. All it requires to handle this step is to listen . . . listen attentively.

As the employe talks, he will elaborate on each point. This will give good clues to the cause of his complaint. With all the facts of the case out in the open, it may be possible to avoid a repeat of this same grievance.

For instance, the employe's complaint may be about his supervisor. He wants to change to some other work in the refinery. When top management listens to the complete story, it is possible to get down to the true cause—why the employe doesn't get along with his supervisor.

This makes it possible to correct the cause—either the foreman's or the employe's attitude. It will avoid having the same problem come up again in the refinery if some definite action is taken to make the supervisor aware of this trouble in his department.

Listening attentively encourages open discussion. When the worker does not go into detail, the listener can encourage him to give more facts. One way is to look at the employe registering the grievance with a ques-

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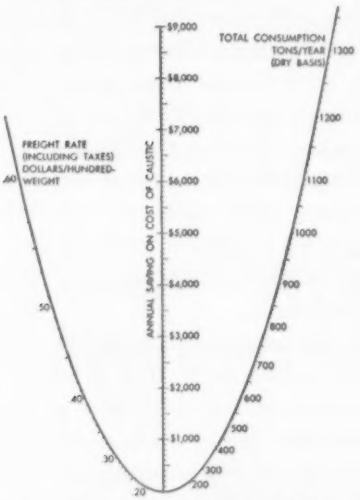
BRIEFS
for heavy-chemical buyers

50% or 73% Caustic? Choosing a supplier Air-conditioned $AlCl_3$

50% to 73%—
some save, some don't

To estimate quickly whether you can save by switching from 50% to 73% liquid caustic soda, simply draw a line on this nomograph.



Start at your freight rate and draw to your annual consumption in tons, dry basis. Your approximate savings on freight will appear where you intersect the center line.

From this figure, subtract annual depreciation for dilution equipment. (We'll be glad to advise you on cost of this equipment.)

If you still show a saving, it would be wise to consider the big switch seriously.

For more facts on the economics of 50% and 73% caustic, check the coupon for a copy of our pocket-size *Caustic Soda Buyer's Guide.*

And for specific technical advice centered on *your* requirements, just phone or write the nearest Hooker sales office.

Choosing a supplier

Service is a large part of what you pay for when you buy caustic soda.

Here are some important "service" points to look for when you're considering a source of supply. (As a Hooker customer, you enjoy *all* of them.)

1. Supply security. How flexible are your supply lines? For instance, a supplier with plants and stock points on deep water may be able to offer you a choice of rail or water delivery. This can assure you steady supply in case of rail service interruption.

2. Realistic contracting. Your agreements with your supplier should realistically reflect your expected needs *and* the supplier's ability to consistently deliver the tonnage you need. Best yardstick for measuring this ability is a supplier's performance record. Hooker, for example, has an unbroken 50-year record of fulfilling contract commitments.

3. Engineering help. A supplier's engineering staff can help you set up a new caustic handling system—or revamp an old one—with advice, and with actual design assistance.

4. Safety programs. The men in your plant who handle caustic soda can benefit from safety suggestions offered by your supplier. You should have on tap the latest in safety equipment, plus up-to-date information on the safe handling of caustic soda.

We'd be happy to enlarge on these points, with your caustic requirements in mind. A phone call or note to the nearest Hooker sales office will bring you the specifics.

Why we air-condition our aluminum chloride.

Even slightly humid air reacts swiftly with aluminum chloride. When it does, the crystals of this sensitive chemical lose their shape, and most of their punch as catalysts.

We avoid such damage to our aluminum chloride by using a special air-conditioned packaging room. It gives us complete control over humidity. Regardless of outside weather conditions, we can package aluminum chloride all year 'round.

To you the room means a continuous, dependable supply of full-strength aluminum chloride. And you always get the size you want for your process.

Speaking of size, you have a choice of four from Hooker—extra fine, fine and coarse grinds, and coarse screened. Send the coupon for a data sheet that gives complete specifications on all four, or write today on your business letterhead.

Check items you'd like to receive:

☐ *Caustic Soda Buyer's Guide.* Lists advantages of 50% and 73% solutions; comparative costs; capacities of tank cars and other containers; useful shipping information.

☐ Technical data on caustic soda.

Need information on these other Hooker products used in the petroleum industry? Check here for technical data sheets:

☐ Aluminum Chloride, anhyd.
☐ Antimony Trichloride
☐ Muriatic Acid
☐ Sulfur Chlorides

Clip and mail to us with your name, title, company address.

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HOOKER ELECTROCHEMICAL COMPANY

1605 FORTY SEVENTH STREET, NIAGARA FALLS, N. Y.

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Pick a card ...any card

• • • On it you'll find the answer to a certain refinery tubing problem. These 24 different steel tube analyses are the result of over 60 years of work and research in the refinery field. Each analysis has been developed to counteract specific refinery conditions ranging from corrosion to high pressures and temperatures. Each analysis has been tested again and again in actual refinery service so that our engineers know its exact capabilities and limitations. In addition to the two dozen analyses shown here, other chemical compositions are available in tubular products, and a wide variety of temperature problems are presently under study.

So pick a card—the analysis you think will meet your refinery tubing needs. But, to be sure before you order, contact us. We have a technically trained Mill Service Force available to you for technical and operating assistance in meeting your tubular requirements. This Force is also available for consultation in the field. We might be able to save you money by selecting a better alloy, at lower cost, to meet your problem. Service is as much a part of our business as is selling pipe. Let us hear from you.

★ ★ ★

Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

TWO DOZEN DIFFERENT NATIONAL TUBE ANALYSES:

Carbon	8 Cr, 1 Mo
Carbon, ½ Mo	9 Cr, 1 Mo
1 Cr, ½ Mo	12 Cr
1¼ Cr, ½ Mo	12 Cr, Al
2 Cr, ½ Mo	17 Cr
2¼ Cr, 1 Mo	18-8
2½ Cr, ½ Mo, ¾ Si	18-8 Ti
3 Cr, 1 Mo	18-8 Cb
5 Cr, ½ Mo	18-8 Mo
5 Cr, ½ Mo, 1½ Si	25-20
7 Cr, ½ Mo	3½ Ni
8 Cr, ½ Mo	5 Ni

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
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COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS **NATIONAL SEAMLESS PIPE AND TUBES**

SEAMLESS WITHOUT WELDS

UNITED STATES STEEL

tioning glance that silently says, "Yes, go on . . ."

When the questioning pause does not get the worker to talk freely about his complaint, it is possible to use still another effective technique—ask the employe one question, "Yes, and in addition to that?"

SMILE

This is the crucial point in handling the complaint. The employe feels that at last he has found a real friend. He has talked out his problem with someone who was willing to listen. He is ready for some action.

By smiling, the listener makes the employe feel he has a sympathetic friend. He is ready to accept the decision. If the smile is sincere, the employe will be more willing to go along with the final verdict about the complaint.

Smiles are good strategy. Smiles are dangerous, too. A smile that is laughing up the sleeve at the employe will do more harm than good. A smile that looks like a pasted on grin will cause the employe to change his attitude about the grievance handling and to be more demanding.

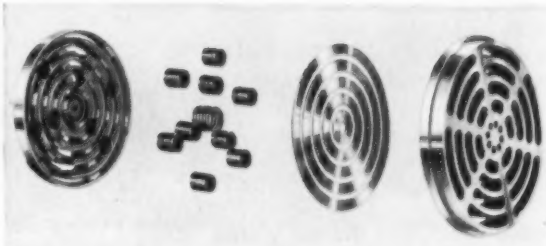
Smiling is easy if the first two steps of this formula for handling grievances have been done in a friendly, sincere manner. It will be a reflection of the attitude of the representative for management. It will leave the employe with a pleasant feeling toward the executive level—both top and middle management—of the refinery.

##

install J.H.H. VOSS VALVES in your compressors for peak performance

(AIR • GAS • AMMONIA)

Our detailed proposal for increasing efficiency of your compressor will be sent without obligation. Send name, bore, stroke, and speed of machine.



Peak performance, maximum efficiency, greater output, and lower power costs can be built into your oldest, and of course your newest, compressors by the installation of VOSS VALVES.

Check THESE VOSS VALVE ADVANTAGES:

✓ Quiet, vibration-free operation ✓ 20 to 60% more valve area
✓ less power consumption ✓ minimum pressure loss ✓ utmost safety
✓ normal discharge temperature ✓ lower operating costs

J.H.H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS CO., INC.
785 East 144th St., N. Y. 54, N. Y.

What's the sense of a spare and a spare spare?

Save money on gauge maintenance. Always keep two gauge glasses "on the bench" for every one in use.

You save time when replacements become necessary, because:

Spare No. 1 is right at hand for immediate replacement during routine cleaning and maintenance of the gauge.

Spare No. 2 is ready for sudden emergencies. Provides quick replacement in case of breakage at night, for example, when your Industrial Distributor may not be open.

Play safe and smart on *all* your visual inspection problems. Call your Industrial Distributor, and order *extra* gauge glasses for all your vessels.

Remember: "ONE FOR THE GAUGE AND TWO FOR THE SHELF." And always specify hard-to-break CORNING®, PYREX® and MACBETH® gauge glasses. It's the economical way.

CORNING INDUSTRIAL GLASSWARE FOR EVERY JOB

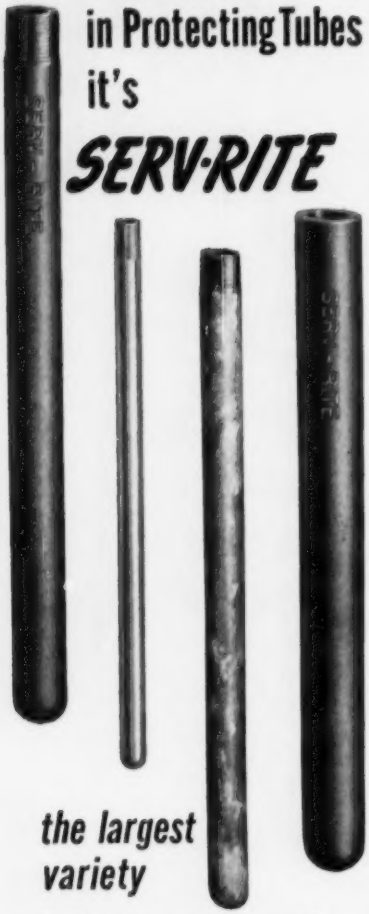
Application	Recommended Product
Normal Conditions (Up to 100 p.s.i.)	CORNING brand standard gauge glasses
Higher temperatures	PYREX brand high-pressure gauge glasses
Higher pressures	PYREX brand heavy-wall gauge glasses
Extra visibility	PYREX brand red-line gauge glasses
Viewing inside furnaces, reactors pressure vessels, etc.	PYREX brand sight glasses
Lubrication inspection	PYREX brand lubricator glasses
Visible discharge devices	PYREX brand oil cup glasses

CORNING GLASS WORKS
Corning, New York

Corning means research in Glass

For more data on advertised products, use Readers' Service Cards, last page.

for any requirement
in Protecting Tubes
it's
SERV-RITE



the largest variety

In size and length, in iron, nickel, and alloys, and in formed or precision drilled, Gordon has about the largest variety of thermocouple protecting tubes. And you get off-the-shelf delivery on most any of this great variety of "standard" tubes. Gordon also makes protecting tubes to specifications for special requirements.

Give Serv-Rite a trial on your next protecting tube requirements. You can't go wrong. Careful manufacture and rigid inspections assure satisfaction. Get full information today. Ask for Bulletin 11-13.

● Bulletin 11-13 gives general application data, specifications, and ordering information on Serv-Rite protecting tubes and protecting wells—the largest grouping in one listing.

6221

CLAUD S. GORDON CO.
Manufacturers · Engineers · Distributors

615 West 30th St., Chicago 16, Ill.
2019 Hamilton Ave., Cleveland 14, O.

THINK Before You Write!

Here is a cleverly presented formula guaranteed to whet your interest in writing better reports.

W. B. Etheridge
Columbian Carbon Company, Conroe, Texas

WHO READ your last report?

Did the boss take it home to read in bed?

In that report did you mention a "permit facilitating acquisition of" or did you just say "permit to buy"?

Using simple language is good sense.

After a glance at the front page of your afternoon paper, you dive for the comics. They are written in a "spoken language." So are the sports pages, too, usually. They have little, short sentences—an idea or two at a time.

Bernard Kilgore of the *Wall Street Journal* once said, "even a Harvard economist is glad to have his time saved by good, clear English."

How do you write a letter to a friend? Did you ever give that friend one of your reports? What was his response? None? (P.S.—He probably didn't read it.)

Dialog will help your report. Use it.

Active verbs and shorter words—Use active verbs to keep writing lively. "John hit the ball" gives you a picture and more sparkle and creates more interest than "The ball was hit by John." Or, more technical, "The pen marked the chart," instead of "The chart was marked by the pen."

Or, "I closed the control damper," instead of "The control damper was closed by the writer of this report." (Your reader may forget who wrote the report before he gets that far if you make it too impersonal.)

Don't leave out all the long words. If they express your exact meaning, use them. They are the spice in the pudding.

"Ethylene Glycol" is definite. "The chemical used in making permanent-type antifreeze" is indefinite.

Don't make your mixture of long words too lean—you must add some gas to the air in your car's carburetor. Be sure the word is clear to you. Be sure the word is clear to your audience! If you have to stumble through a dictionary to find the meaning of a word, think thrice before using it.

Avoid long paragraphs. Breaking up your writing into short paragraphs makes for easier reading.

Words are like women. They are necessary, but when you get too many of them together, confusion results.

A favorite wordy expression in many of our reports is "each and every engineer." Why not "all engineers," or "each engineer?" Do the extra words tell you anything?

To do the best job, the expert uses the right tool.

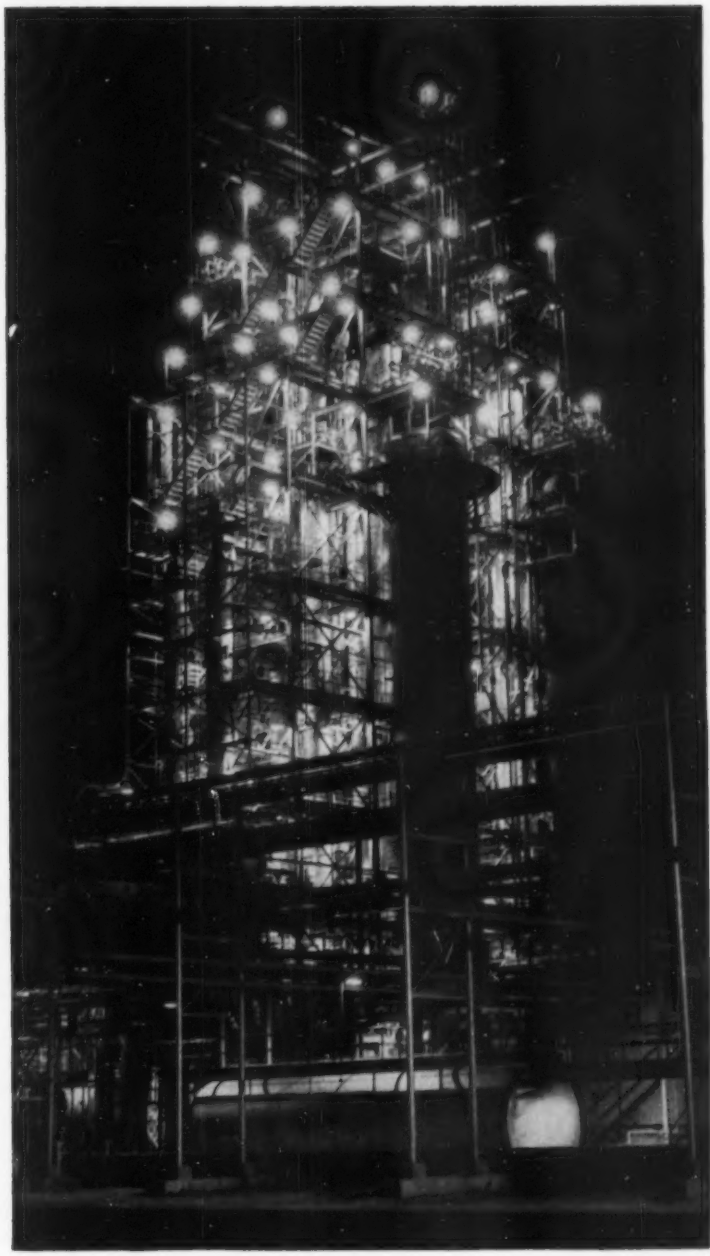
Watch that punctuation! Punctuation is an important tool. Correct punctuation may mark you as an amateur or a professional:

"Mr. Jones," said the teacher, "is a fool."

Mr. Jones said the teacher is a fool.

These are the same words but the tools are used differently, with different results.

An old standby of typists is "Look at this spelling. Some engineer must have written it." Bad spelling need



Night and Day... Year after Year

durable Unibestos insulates vital piping

Pipe insulation shouldn't perform just part of the time. Any time heat escapes, efficiency drops...costs go up. Vital piping requires the kind of continuous protection that single-layer Unibestos insulation provides.

Unibestos is made with Amosite, the quality, long-fiber asbestos with superior insulating properties. Built strong to stay strong, Unibestos resists vibration and shock...withstands steam, acid, and other chemical fumes.

Single-layer Unibestos makes installation simpler, too. It's easily cut, mitered or grooved to fit bends, expansion joints —in fact, all fittings. Unibestos® pipe insulation is available in sectional form through 44" O.D.

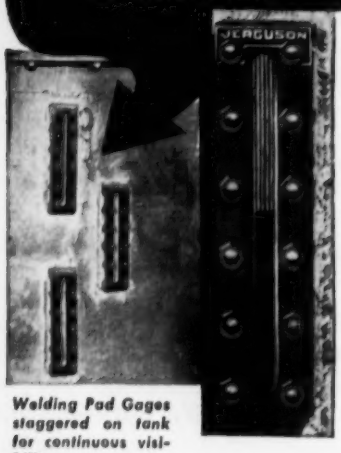
UNARCO

UNION ASBESTOS & RUBBER COMPANY
1111 West Perry Street
Bloomington, Illinois

Joe Bestos says:
UNARCO makes more high-temperature pipe insulation than anyone else!

For more data on advertised products, use Readers' Service Cards, last page.

SPECIAL
JERGUSON
WELDING PAD GAGES
are integral part
of this tank



Welding Pad Gages staggered on tank for continuous visibility.

HERE is a special line of gages that weld right to the liquid containing structure, thus becoming an integral part of it. It solves problems where it is impractical for you to use a conventional type gage because of solids in suspension in a liquid, etc.

These Special Gages follow Jerguson Standard Gages in general design and materials, except for the method of attaching. The chamber of the gage consists of a bar steel pad which is welded to the vessel.

Welding Pad Gages are made in both Reflex and Transparent types . . . in all sizes of Jerguson Standard Gages. Pressure ratings are available to your specific requirements. Welding pad may be of any metal desired to withstand corrosive or other conditions.

Write for Data Unit on Welding Pad Gages for complete details. Whatever your gage problems, let Jerguson engineers assist you.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY
100 Fellsway, Somerville 45, Mass.
Offices in Major Cities
Jerguson Tress Gage & Valve Co., Ltd., London, Eng.
Pétrole Service, Paris, France

As Management Sees It . . .

not be the trademark of engineers. Spelling can mark YOU. Be sure it is a good mark.

Thirty years ago spelling was mastered by a sixth-grade student. Today, some college graduates have not mastered it.

Will your audience dictate that you "go foot," or that you should stand at the head of the line? Generally, good spelling makes sense.

Rules are the life of an engineer—physical laws, chemical laws, natural laws—and without them he could not interpret, predict, or even read and understand results. A few more rules which may profitably be added are those of basic English. How to divide the word. How to add "ing." How to use the apostrophe—*Its* or *It's* never too late to learn?

A recent discussion among a group of engineers was how to add "ing" to age. Out of nine persons asked, four were sure the "e" should be left in.

THINK BEFORE YOU WRITE. THINK BEFORE YOU TALK.

Get yourself organized—The birth of a good report should begin with a period of thought with the object of "Just what do I want to tell my readers?" Make notes. Organize a plan of presentation.

If the discussion of your report covers construction of a building, lay the foundation before you put on the roof. Keep your details and statements in a logical sequence in a discussion.

There is the story of the cub reporter who was sent out to cover a big society wedding. He failed to return to the office or phone in a story. Next morning, he was questioned.

"Oh, there was no wedding," he said. "The bride was run over and killed in front of the church and the groom collapsed and was carried to the hospital," he explained.

Perhaps some very important result happened which was not directly connected with your experiment. This may make a separate and more important report—or eliminate the one you at first proposed to write. THINK, then write.

Work from an outline—be neat! Quality in typing and preparation gives your reader his first impression of your report. Don't hesitate to have a page retyped to make needed corrections.

Ask your typist to use the front of the paper, not the back. She can watch the watermark.

A good outline for a report is

Introduction. Give the purpose of the report and describe the test or process being reported.

Summary. What happened that you are telling about?

Conclusions. What were the results?

Recommendations. How do you think the process could be improved? What changes should be made?

Discussion. How was the test performed? What happened?

Appendix. Insert your charts and other exhibits here if they are for possible reference only. If they fit in closely with the discussion, insert them with it.

Use these headings for all except short reports in which the parts are obvious to the reader—as, one-page reports.

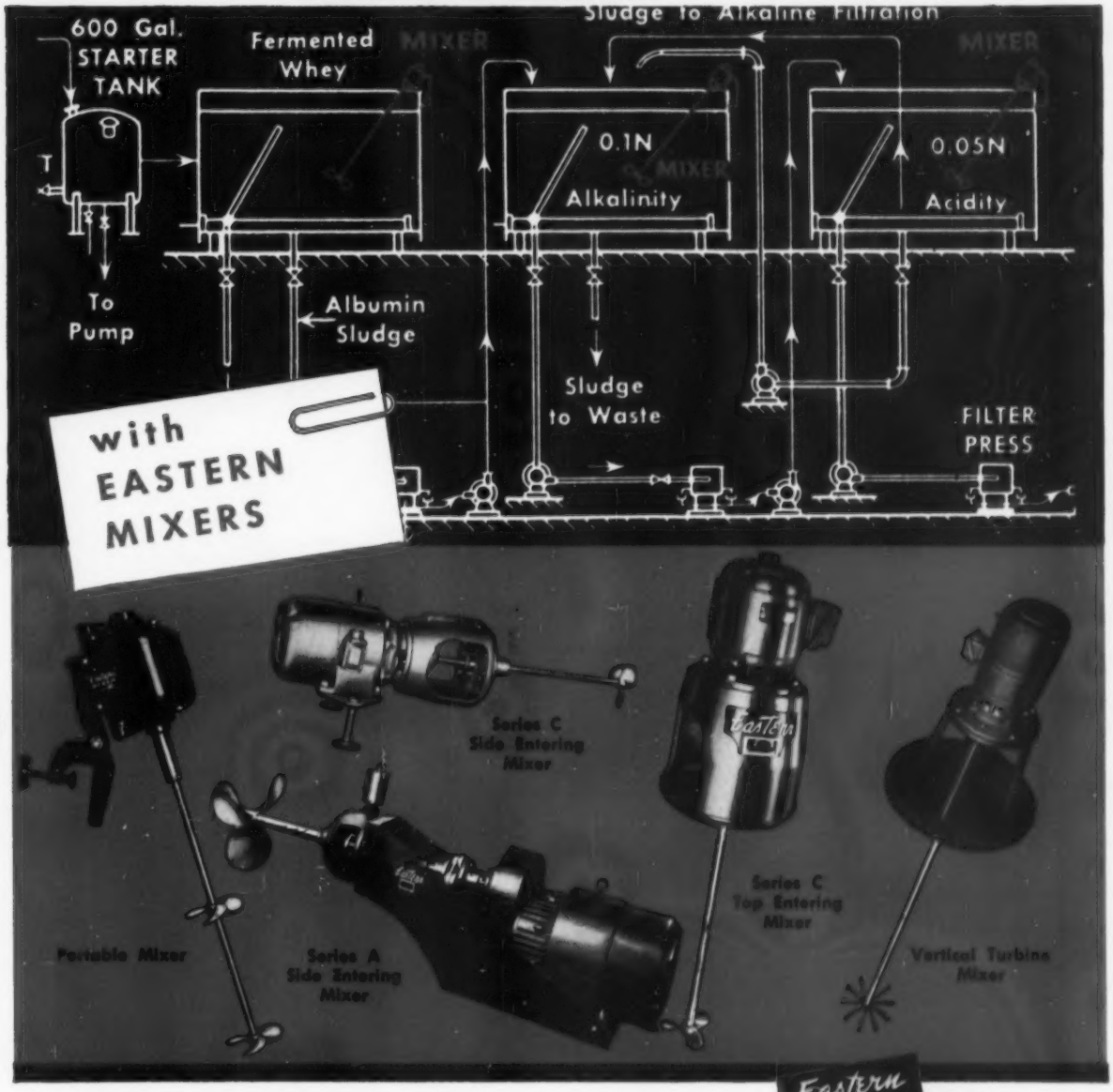
A table of contents is a general outline of the report by headings and page numbers. An index is specific. A long, involved report should have both. Short reports need neither, but a table of contents will help set out the 8 or 10-page report as a work of art. It may distinguish you from an amateur. # #

Meet the Author

W. B. ETHERIDGE, lawyer and former newspaperman, handles various investigating and reporting assignments for Columbian Carbon Company's Carbon Black division, which operates a plant at Conroe, Texas. This work, which he has been carrying on since 1943, is in addition to his legal practice at Conroe. Etheridge is a journalism graduate from the University of Texas and holds a law degree from South Texas School of Law.

For more data on advertised products, use Readers' Service Cards, last page.

RELIABLE FLUID MIXING in PROCESSING



Eastern's Mixers are designed to meet the needs of today's chemical and industrial processes. Many types are available to satisfy all conditions of fluid consistencies and tank sizes. Selection may be made from a wide range of horsepower, speed, and construction materials. Motors with various voltage ratings and enclosures are also furnished.

PORTABLE MIXERS

Series H at 1725 R.P.M., Series S at 1125 R.P.M., and Series G at 420 R.P.M. are available in motor ratings from 1/20 to 5 H.P. Also available are special speeds, variable speeds, as well as air driven models.

TOP AND SIDE ENTERING

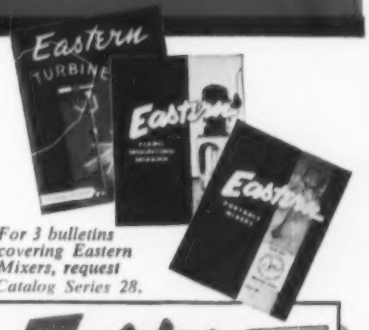
Series A, extra heavy duty for large tanks, are available in side entering units only within a range of 5-30 H.P. with standard speeds of 280, 420, and 1150 R.P.M.

Series C, for average tank capacities, are available in sizes of ¼ to 10 H.P. at these standard speeds: 1725 R.P.M. (up to 5 H.P.); 1140 R.P.M. (up to 10 H.P.); 420 R.P.M. (up to 7½ H.P.); 280 R.P.M. (up to 5 H.P.). Available in both horizontal and vertical models.

TURBINE MIXERS

Eastern's Top and Bottom Entering Turbine Mixers find particular application where liquid blending requires gentle, yet thorough agitation.

Models are available in sizes from ¼ to 40 H.P. Standard speeds are 56, 68, 84, 100, 125, 155 R.P.M.



For 3 bulletins covering Eastern Mixers, request Catalog Series 28.

Eastern INDUSTRIES, INC.
Mixer Division
Regent St., Norwalk, Conn.

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . in the Industry

Write-Off Program Ends; Refining Goal in Sight

With U. S. petroleum-refining capacity due to hit the 9-million-barrel-a-day mark by early 1957, the Office of Defense Mobilization has closed its expansion goal for the first time since the tax write-off program started in 1952.

This action, approved by both the Interior and Defense departments, leaves only one petroleum goal open. Companies installing alkylation facilities are still eligible to receive government tax help.

The write-off program, started during the Korean War to encourage refinery construction, originally had a goal of 8 million barrels a day. This later was increased to 8.75 million.

Write-offs were temporarily suspended in 1955 to permit a review of defense needs. When it was reopened in September, the goal was boosted to 9 million barrels a day, with January 1957 set as a target.

For a list of companies receiving the last write-off certificates, see **Who's Building.**

Shale-Oil Bill Passes Senate

Appropriations for shale-oil research, earlier cut in the House, have been increased in the Senate. The Senate cleared Interior Department appropriations for 1957, adding $1,200,500 to the shale-oil section of the budget to continue research programs at Rifle, Colo., and Laramie, Wyo. Differences in the two bills will be worked out in a joint conference committee.

New Process Emphasizes Trend to Isomerization

Universal Oil Products Company has developed a new isomerization process for use in upgrading pentane and hexane. It will be known as Penex.

Technical details were not announced. But in describing the process, company spokesmen said it "upgrades natural-gasoline and light refinery products; provides a high-octane product with high volatility; affords mild, continuous operation with maximum simplicity; gives clean reaction with no significant loss to by-products, and permits economies in both original investment and day-to-day operation."

This will be the fourth pentane and pentane-hexane process available for licensing. The others were developed by these companies:

- The Atlantic Refining Company—Pentafining, for isomerization of normal pentane to isopentane.
- Shell Development Company—Liquid-phase isomerization for normal butane and normal pentane.
- Standard Oil Company (Indiana)—Isomating, for hexane and hexane pentanes.

Universal predicts its new process will be useful in upgrading natural gasoline as well as low-boiling fractions of straight-run and cracked refinery products.

Elsewhere in the industry, a member of Ethyl Corporation's research staff told refiners they soon will have to look beyond mild catalytic reforming for ways to upgrade gasoline.

Speaking before the Rocky Mountain Oil and Gas Association at its annual meeting in Salt Lake City, T. W. Warren said catalytic reforming has become a requisite part of a refiner's octane-improvement operation. But, he pointed out, the increased severity of reforming required to obtain high octane numbers is making these numbers expensive.

As a result, refiners must weigh the relative costs of various methods of improving gasoline qualities. Warren said that future differences in octane cost will be measured in whole cents per barrel, making great differences between alternative processing methods.

He outlined several process possibilities. They included aluminum-chloride isomerization, a platinum process for either reforming of low-octane naphtha or isomerization of hexanes, alkylation, fractionation of light naphtha, and second-pass reforming. The actual processing scheme of the future, he declared, probably will be a complex combination of octane-improvement methods.

The optimum operation will secure maximum octane improvement at minimum cost. Determination of this optimum operation, however, will justify or require computer applications and programming techniques as yet undeveloped.

The incentive for this work is great, he declared, for a difference in cost of 5 cents per Research octane number per barrel would provide a $1000-a-day dividend in a refinery producing 20,000 barrels of gasoline a day if the last octane number is secured by optimum operation.

Mid-Western Lubricating-Oil Figures Released for February

Western Petroleum Refiners Association has released its statistics on Mid-Western Lubricating Oil for February 1956. The table summarizes operations of 12 reporting companies which manufacture lubricating oils in the Mid-Western area.

	(Figures in Barrels of 42 Gallons)						
	Total Bright Stock	Solvent Bright Stock	Total Viscous Neutrals	Solvent Viscous Neutrals	Paraffin Oils	Steam Refined Stock	Blended Oils
FEBRUARY 1956							
Production	239,039	219,325	550,082	500,854	154,464	22,194	665,093
Shipments:							
Domestic	222,565	206,904	539,075	486,820	152,440	17,410	657,336
Export	36,604	30,667	43,781	43,055	5,542	155	42,163
Total	259,169	237,571	582,856	529,875	157,982	17,565	699,499
Inventory February 29	326,630	276,784	602,155	526,195	157,585	34,952	454,815
Days Supply	37	35	32	31	.....	.....	.....
FEBRUARY 1955							
Production	218,688	192,296	494,003	449,424	148,958	16,891	595,244
Shipments:							
Domestic	182,762	168,729	384,486	331,347	136,961	12,644	527,744
Export	54,622	51,739	26,893	26,800	.....	283	76,666
Total	237,384	220,468	411,379	358,147	136,961	12,927	604,410
Inventory February 28	344,422	240,513	685,340	602,629	123,006	34,001	499,712
Days Supply	39	30	42	42	.....	.....	.....

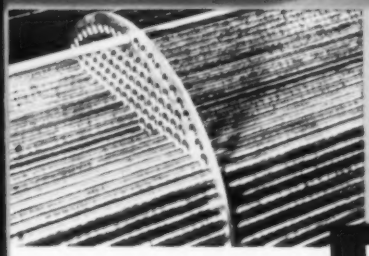
Petrofina Organizes Subsidiary in U. S.

Compagnie Financiere Belge des Petroles has organized a company to take up operations in the U. S. The new company, American Petrofina, Inc., was incorporated in Delaware to engage in all phases of oil operations.

This is the second company organized in the Western Hemisphere by Petrofina. Less than three years ago the Brussells concern formed Canadian Petrofina, Ltd., and built a refinery at Montreal.

Laurent B. Wolters, vice chairman and managing director of the parent company, has been named to serve also as president and director of the new subsidiary.

Named as chief executive officer was W. D. Heath Eves, formerly the parent



STARTLING APPLICATIONS OF INCREASED HEAT TRANSFER

Using WOLVERINE TRUFIN* Type S/T

• CONDENSING STRAIGHT RUN GASOLINE

Located in the plant of a large Mid-West refinery this condenser, originally a plain tube unit, was retubed with Wolverine Trufin Type S/T. Here are the basic facts:

	PLAIN TUBE	TRUFIN TYPE S/T
TOTAL TUBE LENGTH	16,384	10,916
OUTSIDE SURFACE, SQ. FT.	3,215	5,420
METAL	14 BWG Admiralty	16 BWG (Cat. No. 195065) 90-10 Cu. Ni.

RESULTS:

The heat duty of the Trufin-tubed unit was 630,000 BTU's per hour greater than the plain tube condenser. Trufin's performance per foot of length, was 80% greater than the plain tube. In nearly two years of service, the Trufin unit has never required mechanical cleaning. Acidizing every four months has been adequate.

CONCLUSION: *Trufin is a Wise Buy!*

• CONDENSING ORGANIC CHEMICALS

The following data is based on the condensation of Freon-12 with water and was compiled after exhaustive tests under closely controlled conditions:

	PLAIN TUBE	TRUFIN TYPE S/T
SHELL SIZE O. D.	12¾"	12"
TUBE LENGTH	7'	7'
TUBE SPECIFICATIONS	⅝" O.D.—18 BWG 90-10 Cu. Ni.	⅝" O.D.—18 BWG (Cat. No. 195049) 90-10 Cu. Ni.
OUTSIDE SURFACE SQ. FT.	143.34	334.0

RESULTS:

On the basis of equivalent water velocity the prime surface unit extracted 411,000 BTU's per hour. The Trufin-tubed unit obtained 829,000 BTU's per hour.

CONCLUSION: *Trufin is a Wise Buy!*

• CONDENSING CRACKED GASOLINE

When tubed with plain tube, this superstructure mounted condenser, had to be mechanically cleaned every three months. In an effort to boost capacity, extend on-stream time, and eliminate the necessity of designing new exchangers, it was retubed with Wolverine Trufin Type S/T. Here are the vital statistics:

	PLAIN TUBE	TRUFIN TYPE S/T
NO. OF TUBES	500	500
OUTSIDE SURFACE AREA, SQ. FT.	1522	3280
METAL, ¾" O. D.	16 BWG Admiralty	16 BWG (Cat. No. 195065) Admiralty

RESULTS:

Heat duty jumped from 3,960,000 to 5,820,000 BTU's per hour with the Trufin bundle. Retubing permitted a 38% increase in throughput and a 47% increase in heat removal with a very large increase in length of run.

CONCLUSION: *Trufin is a Wise Buy!*

These are but three of many installations where Trufin is injecting greater performance into existing equipment. When retubing existing condensers or designing new ones, always specify Trufin Type S/T. For further information complete with case histories and design data, write for your copy of Wolverine's Trufin Opportunity Book. Do it today!
WOLVERINE TUBE, 1437 Central Avenue, Detroit 9, Michigan.

*REG. U.S. PAT. OFFICE

PLANTS IN DETROIT, MICH. AND DECATUR, ALABAMA.
SALES OFFICES IN PRINCIPAL CITIES

EXPORT DEPARTMENT, 11 EAST 40TH ST., N.Y. 16, N.Y.

DIVISIONS OF CALUMET & HECLA, INC.

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GOODMAN LUMBER CO.

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.

Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

STARTLING FACTS ABOUT HEAT TRANSFER

Where and how WOLVERINE TRUFIN* Type S/T Can Help You CUT COSTS, BOOST PERFORMANCE!

CHECK LIST OF TRUFIN TYPE S/T ADVANTAGES THAT WILL HELP YOU SAVE

Trufin—with fins squeezed directly from the tube wall—has more than twice the heat transfer surface of plain tube. You need less tube because Trufin transfers more BTU's per foot of tube!

Fewer tubes mean smaller shells, headers, baffles . . . substantial savings in material requirements!

Less tubes mean less holes to drill—fewer rolling-in operations . . . a direct saving in time and labor costs!

Trufin requires much less over-all tube metal to transfer a given heat load. This means a real saving when expensive alloys are necessary . . . vital when alloys are in short supply!

Because Trufin installations require fewer tubes you can often design lighter units. Think of what this means when superstructure mounting is required!

Maintenance costs go down and stay down. Replacement tube costs are reduced, on-stream time increases because fewer tubes mean less cleaning time is necessary. Actual operating data shows that Trufin withstands fouling for longer periods of time than does prime surface tube. Operating time between change-overs is lengthened!

Trufin is completely interchangeable with prime surface tube. You follow standard retubing techniques!

Trufin withstands vibration, sudden temperature changes and pressure variations. Fin life is equal to that of the tube itself.

On the left, below, you'll find some basic reasons for the outstanding performance of Wolverine Trufin Type S/T—the integral finned condenser tube. You'll also find, below, a partial list of operations where Trufin can be used to good advantage. Study both lists carefully—check them against your own heat exchange operations—see for yourself just where and how Trufin can help you do a better job.

A FEW OF THE APPLICATIONS WHERE TRUFIN TYPE S/T CAN HELP YOU

- In Butane Condensers
- In Propane Condensers
- In Gasoline Condensers
- In Isopropyl Condensers
- In Condensing Butyl Heads
- In Gas Coolers
- In Condensing Organic Chemicals
- In Boiling Hydrocarbons
- In Heating or Cooling Gases
- In Heating or Cooling Oil or other liquid Hydrocarbons

As we have said—study these points. They can be your check list to greatly increased efficiency and economy in your heat exchange applications. Wolverine's new Process Flow Sheet Book contains many drawings of actual Trufin installations. Write today for your copy. WOLVERINE TUBE, 1437 Central Avenue, Detroit 9, Michigan.

Wolverine Trufin available in Canada through the Unifin Tube Company, London, Ontario.

*REG. U.S. PAT. OFFICE

505W42—5106

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Division of Calumet & Hecla, Inc.

Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

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company's representative in the U. S. He was made executive vice president and director.

Vice president and treasurer of the company will be Roger Gilbert, president of Panhandle Producing & Refining Company, in which Petrofina has acquired an interest. He also will be a director.

Another Panhandle officer elected as an executive of the new Petrofina subsidiary is Hughes Duffy, who was made secretary. He is secretary of the Panhandle company.

Named as directors of the company are Alfredo Campo, executive vice president of Canadian Petrofina; J. Howard Marshall, formerly with Signal Oil & Gas Company and, before that, Ashland Oil and Refining Company, and Gustav Peter Fleck, president of Amsterdam Overseas Corporation. A seventh director will be selected later.

Cosden and Grace Agree on Merger

Acquisition of Cosden Petroleum Corporation by W. R. Grace & Company has been agreed upon by executives of both companies.

The merger will be recommended to the companies' directors at meetings to be held in May. Subsequently, the proposal will be submitted to stockholders for final action.

Cosden, with a refinery at Big Spring, Texas, has been diversifying its output. Recently, it completed a styrene plant operated in conjunction with the refinery.

Grace is an international chemical manufacturing, transportation and trading concern.

Explosion, Fire Hit Marcus Hook Plant

Sun Oil Company has been hit by explosion and fire at its 300-ton-a-day ammonia plant in Marcus Hook, Pa. The plant, struck April 19, is not expected back in operation for several months.

Fire started when an explosion in the plant's air-purification unit ignited hydrogen in an adjoining unit. Cause of the explosion had not been determined.

Damages have been estimated at less than $3 million. The plant, which cost $10 million, went on stream early this year. It was the largest ammonia plant using hydrogen from refining.

Shell Crude Capacity Shows 1955 Increase

Completion of Shell Oil Company's refinery at Anacortes, Wash., and improvements at the Norco, La., refinery increased the company's total crude-processing capacity from 504,000 barrels a day to 561,000 barrels by the end of 1955.

The company's refineries operated practically at full capacity during the year. An annual report shows that crude-oil runs to distilling units at Shell refineries totalled 168,986,000 barrels. This is an increase of 11,634,000 barrels, or 7 percent, over 1954.

Texaco Film Tells Story Of Integrated Operations

The complete story of an integrated oil company's operations—exploration, producing, refining, transportation, marketing and research—is portrayed in a 30-minute, 16-mm color film, "The Story of a Star," just released by The Texas Company.

Two years in the making, the movie covers the entire scope of petroleum operations and provides a broad documentary view of a basic American industry.

The film is available on a free loan basis from the Public Relations Office of The Texas Company in Houston and from other Texaco locations throughout the country.

D-X Sunray Installs Spectrograph Unit

D-X Sunray Oil Company has installed a $50,000 spectrograph laboratory capable of analysing more than 70 elements. The equipment is part of the company's Research and Technical Service department at its refinery in West Tulsa.

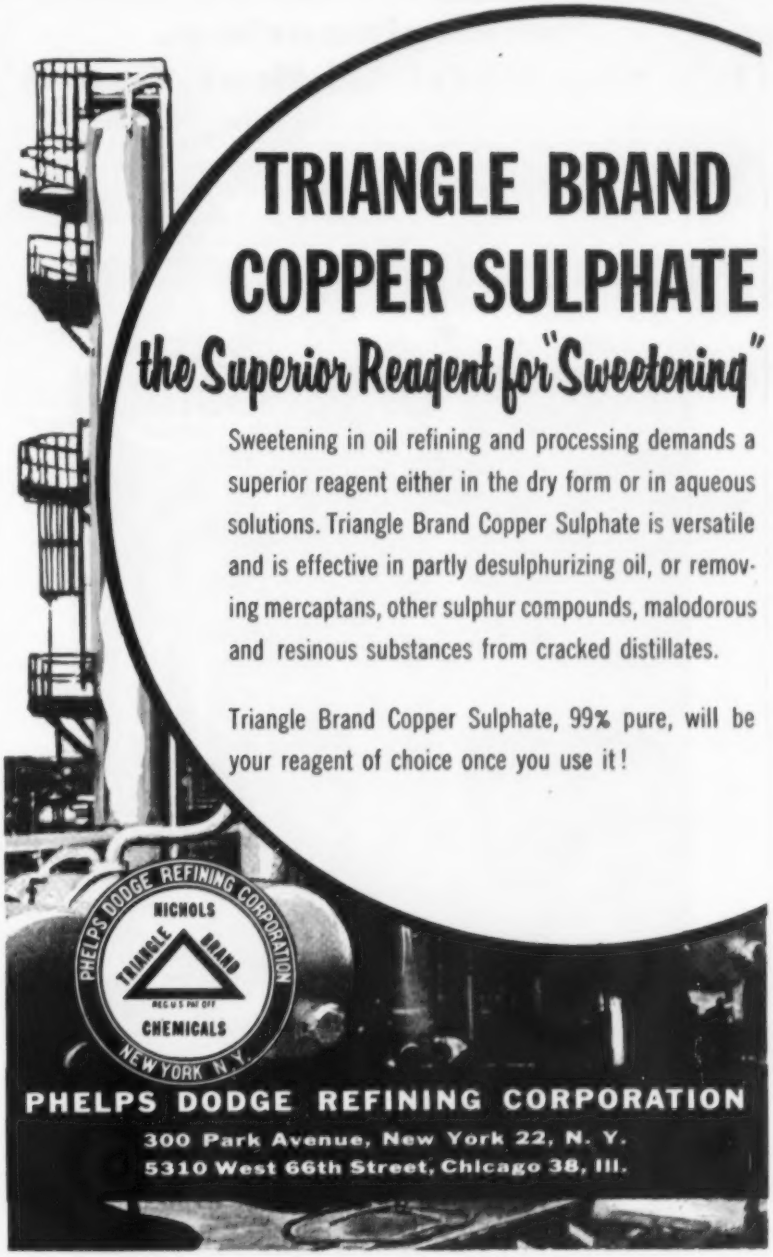
Largest spectrograph laboratory of its type in the area, the equipment features a Jarrel-Ash 3.4 meter emission spectrograph. The facility will be used primarily for processing petroleum and petroleum products.

Goodrich-Gulf Places Institute Plant in Operation

Goodrich-Gulf Chemicals, Inc., has started production of synthetic rubber at the formerly government-owned Institute, W. Va., plant. The plant, which had been idle since 1953, was purchased from the government for $11 million.

The company now has one of three production lines in operation turning out

What's Happening . . .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Sweetening in oil refining and processing demands a superior reagent either in the dry form or in aqueous solutions. Triangle Brand Copper Sulphate is versatile and is effective in partly desulphurizing oil, or removing mercaptans, other sulphur compounds, malodorous and resinous substances from cracked distillates.
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What's Happening . . .

GR-S type rubber. When in full operation, the plant has a capacity of 122,000 long tons a year.

Procon Forms Company For Building Overseas

Procon, Inc., has formed a new subsidiary, Procon International, S. A., to handle its petroleum-process construction activities outside the U. S. The firm will headquarter in Chicago, with a branch office at Santiago de Cuba.

C. B. Whyte, president of Procon, Inc., also heads the international subsidiary. J. C. Reed and A. G. Petkus are vice presidents; J. E. Quinn, secretary, and A. J. Rohrman, treasurer.

Safety Award Goes To Foster Wheeler

National Constructors Association has made a safety award for 1955 to Foster Wheeler Corporation.

The association is made up of engineering and building firms engaged in construction of chemical plants, petroleum refineries and other heavy industrial installations.

In 1955, the association had an average frequency rate of 16.1 and an average severity rate of 0.85. The construction industry as a whole had a frequency rate of 17.29 and a severity average of 2.29 in 1954, the latest year for which figures are available.

"In Engineering, It's the PEOPLE that Count"

The SOHIO catalytic poly feed treating unit shown below is an example of C. W. Nofsinger Company engineering . . . from start to finish. Field "extras" for construction and operating changes were insignificant because the original drawings were complete in every detail.

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2,500 BPSD catalytic poly feed treating unit now in operation at SOHIO'S Lima, Ohio, refinery.

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Engineers and Contractors for the Petroleum and Chemical Industries

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ASME Holds Classes In Engineering-Management

Engineering management training courses in the Los Angeles area have been undertaken by ASME's Management Division of Southern California. Two classes, to be held this month in Pasadena and Long Beach, will be conducted by Floyd Graham & Associates, a management-consulting organization.

The courses were set up by the society in recognition that managers are being developed from the ranks and that properly-trained engineers fit well into management positions.

The first course in the society's two-year program was held last fall. This was oversubscribed, and ASME scheduled its new classes. The instructor will be William C. Urlovic, Floyd Graham's consultant in management engineering.

All engineers in the Los Angeles area are eligible to attend. Membership in ASME is not required.

MIT Sets Sessions On Polymerization

"Recent Advances in Catalytic Polymerization" will be the subject of a special two-week summer program to be held at Massachusetts Institute of Technology June 17-27. The program, directed to research workers in polymerization and allied fields, will consist of lectures, discussions and demonstrations.

Full details may be obtained by writing Summer Session Office, Room 7-103, Massachusetts Institute of Technology, Cambridge 39, Mass.

Act of Congress Needed To Transfer Hawaii Site

Department of Justice believes an act of Congress will be required to transfer title of a government-owned tract on Sand Island in Honolulu Harbor wanted by Standard Oil Company of California for the site of a new refinery. This was reported by the company's president, T. S. Petersen, at a meeting of stockholders.

Government Sees Leaders In Butadiene Industry

Two petrochemical concerns will be the largest U. S. producers of butadiene when the synthetic-rubber industry completes its present expansion program.

According to a Justice Department report to the President, Petro-Tex Chemical Corporation will be the country's largest butadiene maker, with Phillips Chemical Company second.

Together, the two companies will account for more than 70 percent of the industry's more than one-third expansion. The expansion, due to be completed in 1957, will raise U. S. butadiene output to 718,000 tons a year.

The report, delivered by Attorney General Brownell, was made in accordance with a directive from the Senate Banking Committee ordering the Justice Department to watch any trend toward concentration of synthetic-rubber capacity.

Kerr-McGee to Purchase Cleveland, Okla., Plant

Kerr-McGee Oil Industries, Inc., has agreed to purchase the Gaseteria, Inc., refinery at Cleveland, Okla. The refinery, formerly owned by Johnson Oil Refining

For more data on advertised products, use Readers' Service Cards, last page.

IF YOU ARE CONCERNED WITH HIGH OCTANE OPERATIONS

INVESTIGATE THE EXTRA EFFICIENCY OF Sinclair-BAKER RD 150 PLATINUM CATALYST

BAKER'S RD 150 Platinum Catalyst is a joint development of Baker & Company, Inc. and Sinclair Research Laboratories. This peak-production catalyst is now used with marked advantage by such companies as Sinclair, Socony and Pure Oil.

REGENERATES IN SITU . . . !

RD 150 provides high initial efficiency plus unique regenerative features. RD 150 assures greater yields at high octane levels, exceptionally long periods of operation, PLUS additional economy made possible by regeneration in situ! We are quite confident that the full story of Baker's RD 150 will be intensely interesting to you.

You can also be relieved of delivery and service problems. Modern Baker plants are geared for large-scale manufacture and refining of platinum catalyst.

Upon request, a Baker representative will be glad to consult with you and to furnish detailed information and recommendations.

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Since 1940

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Company, will be bought at a salvage price.

Kerr-McKee, through its refining subsidiary, Deep Rock Oil Company, will continue to operate only the refinery's Platformer. The unit will process naphtha transported to Cleveland from the company's Cushing refinery.

No decision has been made on the use of the other facilities at Cleveland. They include a thermal-cracking unit.

Shell Group Earmarks $1 Million for Gifts

Shell Companies Foundation, Inc., will contribute more than $1 million to educational, charitable, religious and public-service organizations in 1956.

This amount, one of the largest in the industry, is allocated from gifts made to the foundation by Shell companies.

Approximately $450,000 will go for educational programs. This is an increase of $100,000 over the amount the foundation spent for education in 1955.

Shell will provide 50 graduate fellowships and 20 grants for fundamental research to 42 colleges and universities throughout the U. S. It also is starting a program to back the education of engineers and scientists by awarding fellowships to high-school science teachers.

Copies of Index Still Available

Copies of the 1955 PETROLEUM REFINER Index, which in the past always has appeared in the December issue, are still available to subscribers—now upon request. Readers who want this valuable guide to the past year's advancements in refining, petrochemicals and natural gasoline should use the Reader's Service green card in the back of this issue. Write on the card, "1955 PETROLEUM REFINER Index," fill in name, address and mail. There is no charge or obligation.

Union Debentures Sold to Gulf Oil

Union Oil Company of California has sold $120 million worth of 25-year subordinate convertible debentures to Gulf Oil Corporation. The transaction did not represent a merger of the two companies.

The debentures are to be converted into common stock at $70 a share during the first five years, $75 during the next five years, and $80 during the third five-year period, after which the conversion privilege ended.

Gulf already has purchased $60 million worth of debentures and is expected to buy additional $60 million worth during the next year.

Should Gulf decide to convert all the debentures into common stock, it will be obliged to make further payment of $48 million if the conversion comes during the first five years, $60 million if the conversion occurs during the second five years, and $72 million if it is in the third five years, increasing Gulf's total investment accordingly.

Should all the debentures be converted as outlined, Gulf would then own 2,400,000 shares of Union stock.

British American Offers To Buy Gulf Subsidiary

The British American Oil Company, Ltd., has offered to buy Canadian Gulf Oil Company, producing concern and Alberta natural-gasoline manufacturer.

In consideration, the parent Gulf Oil Corporation would receive an issue of restricted British American common stock.

The offer will be presented to shareholders of British American for final action at a special meeting to be held later this month. Gulf Oil's executive committee already has authorized that company's management to accept the offer.

British American made the proposal to improve its position with regard to a low ratio of crude production to refinery thruput. Combined production of British American properties in the U. S. and Canada was less than a third of refinery requirements in 1955.

What's Happening . . .

Esso Research Contracts Additional Atom Work

Esso Research & Engineering Company has engaged the Battelle Memorial Institute in Columbus, Ohio, to conduct experiments aimed at perfecting ways of using nuclear radiation in petroleum refining and petrochemical production.

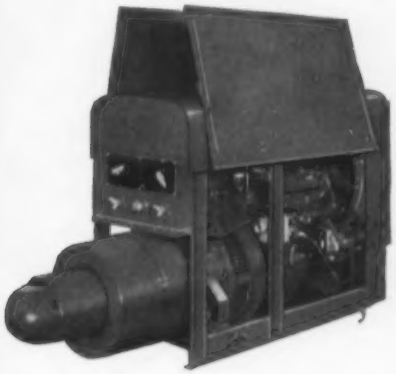
In its own radiation laboratory at Linden, N. J., Esso has indicated possibilities

When Lincoln makes the most popular gasoline and diesel engine-driven welders...

Has the best line of electrodes for pipe work...

Yet costs no more to buy and operate...

WHY buy anything but LINCOLN



In every part of the world

LINCOLN "SHIELD-ARC" SA-200

200 amp. engine-driven welder

paces the refinery industry with:

- rugged, dependable operation for heavy sustained welding
- dual control of arc voltage and welding current to suit each specific job
- low operating cost for fuel and maintenance because of exclusive engine idling control

That's why practically all oil field operators prefer Lincoln Shield-Arcs.

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The World's Largest Manufacturer of Arc Welding Equipment

Send Bulletin SB-1337 on Lincoln Shield-Arc Engine-Driven Welders

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TO PLUG PIPE ENDS TEMPORARILY

In Order To:

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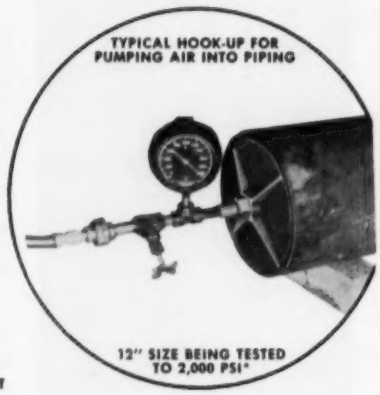
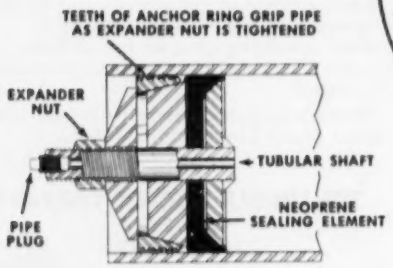


*COLD WATER, NON SHOCK TEST MADE IN 12¾" O.D. STANDARD WEIGHT LINE PIPE.


TEETH OF ANCHOR RING GRIP PIPE AS EXPANDER NUT IS TIGHTENED
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What's Happening . . .

for the use of irradiation processing in the petroleum industry. For instance, same quantities of gasoline and other oil products have been produced there with the aid of gamma radiation.

Foundation to Build Reactor for Industry

The first nuclear reactor in the U. S. designed specifically for industrial research is being built at Armour Research Foundation of Illinois Institute of Technology in Chicago.

The reactor, a $700,000 installation, is being built by the foundation in partnership with 19 companies. Each company is contributing $20,000, and the foundation is providing the remaining funds.

Companies participating will share in the benefits of a three-year program aimed at applying atomic techniques to industrial problems. The plan includes detailed technical advice, certain patent benefits and specialized training.

Monsanto Increases Program to Aid Colleges

Monsanto Chemical Company has expanded its program of financial aid to scientific education for the 1956-57 school year.

A total of 83 colleges and universities will benefit from 111 separate direct-aid awards under the program. This is an increase of 30 in the number of schools aided and 39 in the number of awards over the company's 1955-56 program.

The awards will include 29 fellowships, 41 undergraduate scholarships and 41 cash grants.

The fellowships are for graduate studies with the larger part of their $3000-average value going to the individual. The scholarships are intended to cover tuition costs.

Cities Service Closes Petrochemical Plant

Cities Service Oil Company is closing its petrochemical plant at Tallant, Okla. The plant, built in 1928, has been manufacturing formaldehyde. The company will sell the equipment and materials.

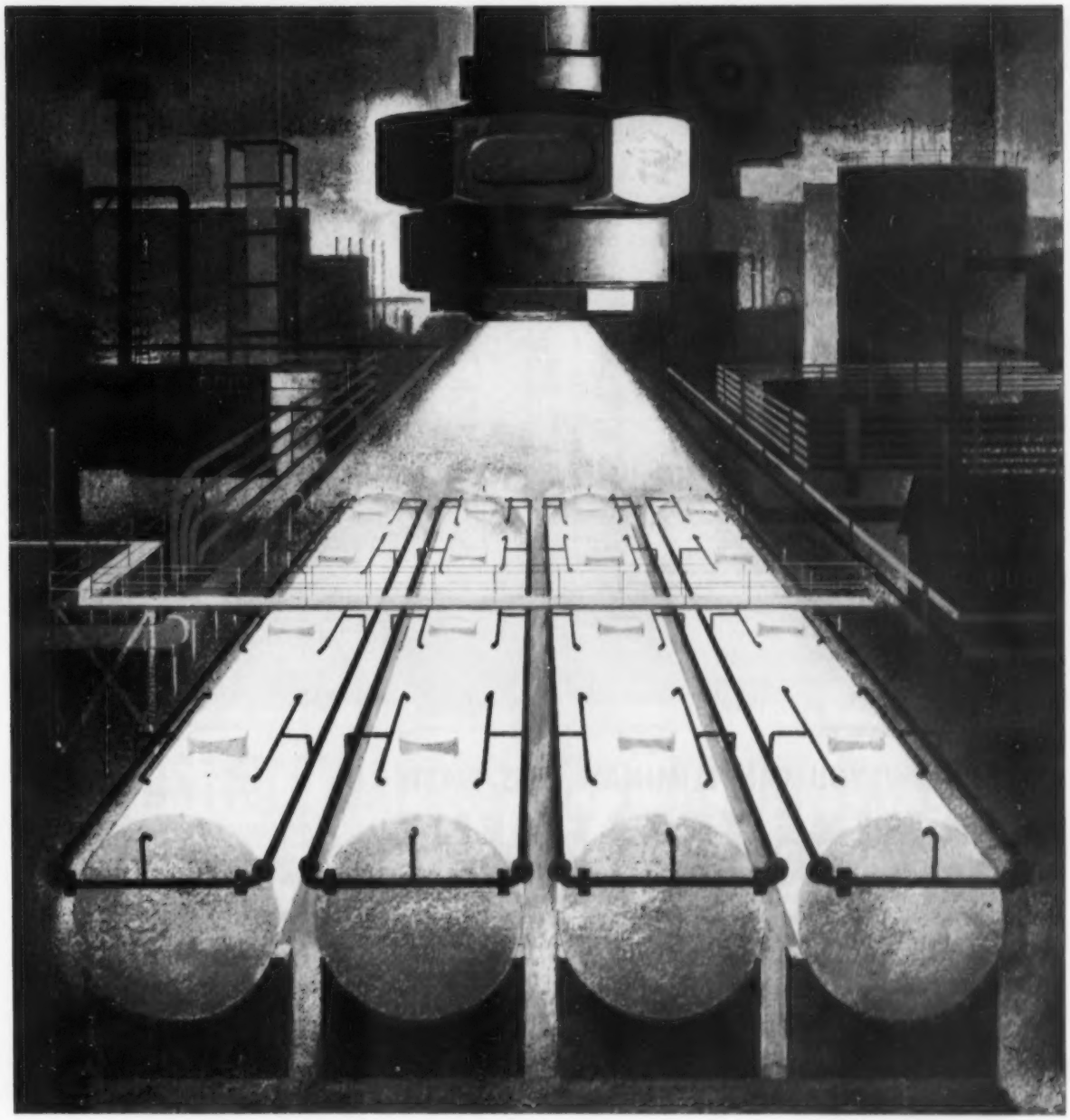
U. S. Octane Average Hits 96.3 for Premium

Gasoline on sale at service stations in April showed a national weighted average of 96.3 octane number for premium and 89.3 for regular, according to a monthly survey compiled by Ethyl Corporation.

Another survey, conducted by E. I. du Pont de Nemours & Company, reports the national average for premium at 96 octane numbers for the first quarter of 1956. This figure has increased 0.1 of a number since the last Du Pont report.

Du Pont's survey shows the quarterly average for regular gasoline at 89 as compared to 88.8 in the last report.

According to Ethyl, the premium-gasoline average in April was 0.1 octane number below March but 1.1 numbers higher than in April 1955. The regular-gasoline average was unchanged from



give your plant and equipment the best fire protection— a BLAW-KNOX automatic fog system

BLAW-KNOX Automatic Fire Protection Systems are engineered to provide positive protection for your plant and processing, storage, and other equipment. If a fire breaks out, the system goes into action immediately:

- **alarms sound**
- **fire smothered *promptly***
- **heat dissipated by *cooling* action**
- **pressure build-up prevented**

Why not give your plant and equipment the BEST possible protection. Let a Blaw-Knox *fire-protection* Engineer study your needs. He will gladly submit a layout and a cost estimate . . . with no obligation to you.

"Little Joey Sprinkler always on the job"

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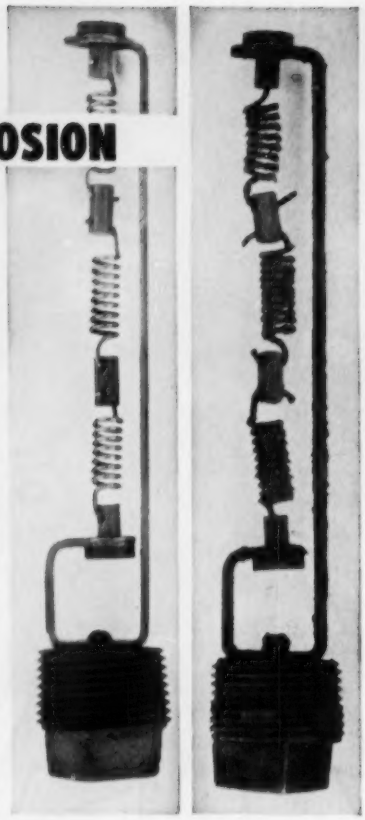
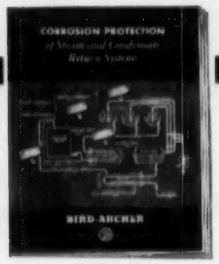
HERE'S HOW RETURN LINE CORROSION REDUCES POWER PLANT EFFICIENCY...



Return line corrosion is one of the most critical problems in maintaining economical, efficient power plant operation. To demonstrate what corrosion can do in steam and condensate return lines, we show here "before" and "after" unretouched photographs of N.D.H.A. Corrosion Testers. This is a test* developed by the American Society for Testing Materials in cooperation with the National District Heating Association. Bird-Archer supplies and analyzes these testers. Photo at left shows a Tester before installation. Photo at right shows a Tester after it had been installed for 60 days in the return line. (*Standard Method of Corrosivity Test of Industrial Water, NDHA Method, ASTM Designation 935-49).

HERE'S HOW YOU CAN ELIMINATE THIS WASTE WITH AMINE TREATMENT

Bird-Archer Amine Treatment is an easy, effective and economical way to eliminate corrosion troubles. Amines raise the pH value of the return condensate to the point whereby the corrosion potential is negative. In addition, amines provide a surface protection for the metal itself which further inhibits corrosion. In scores of plants, Bird-Archer Amine Treatment is paying a profit on its cost through savings in piping replacement and maintenance work.



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AND THE NAME OF THE BIRD-ARCHER SERVICE ENGINEER NEAREST YOU.

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BIRD-ARCHER COMPANY OF CALIFORNIA, San Francisco

What's Happening . . .

March and 1.6 numbers higher than a year ago.

Compared with the nationwide premium average of 96.3 octane numbers, 15 cities of the 53 covered in the Ethyl survey reported premium averages of 97 numbers or higher. In regular gasoline, 15 cities showed ratings of 90 octane or higher.

Nine cities taken up in the quarterly Du Pont survey had average premium research octane numbers of 97 or more, with two reporting 97.5. The highest premium sample tested by Du Pont was 98.6 octane numbers.

One city was found with a regular average of 92.2 for the quarter, and other averaged as high as 92.

Brooklyn Polytech Sets Laboratory Program

Polytechnic Institute of Brooklyn has scheduled its 1956 summer Laboratory Program for Industry. Six courses in laboratory techniques will be offered for industrial researchers.

One- and two-week courses, with eight-hour-a-day laboratory sessions in addition to evening lectures, will cover these fields:

- Industrial Applications of X-ray Diffraction, May 28-June 8.
- Applied Infrared Spectroscopy, June 4-8.
- Polarography and Related Techniques, June 11-15.
- Progress in Polymerization and Copolymerization Techniques, June 18-22.
- Properties of Macromolecules in Solution, including Polyelectrolytes and Other Water Soluble Polymers, June 25-29.
- Applications of Ion Exchange Resins and Membranes, July 23-27.

Enrollment in each course is limited to 20 students.

Queen City OK's Sale Of North Dakota Refinery

Sale of Queen City Oil & Refining Company's refinery at Dickinson, N. D., has been authorized by the directors. The refinery, with a daily capacity of 2500 barrels, has been running 900 barrels of crude a day.

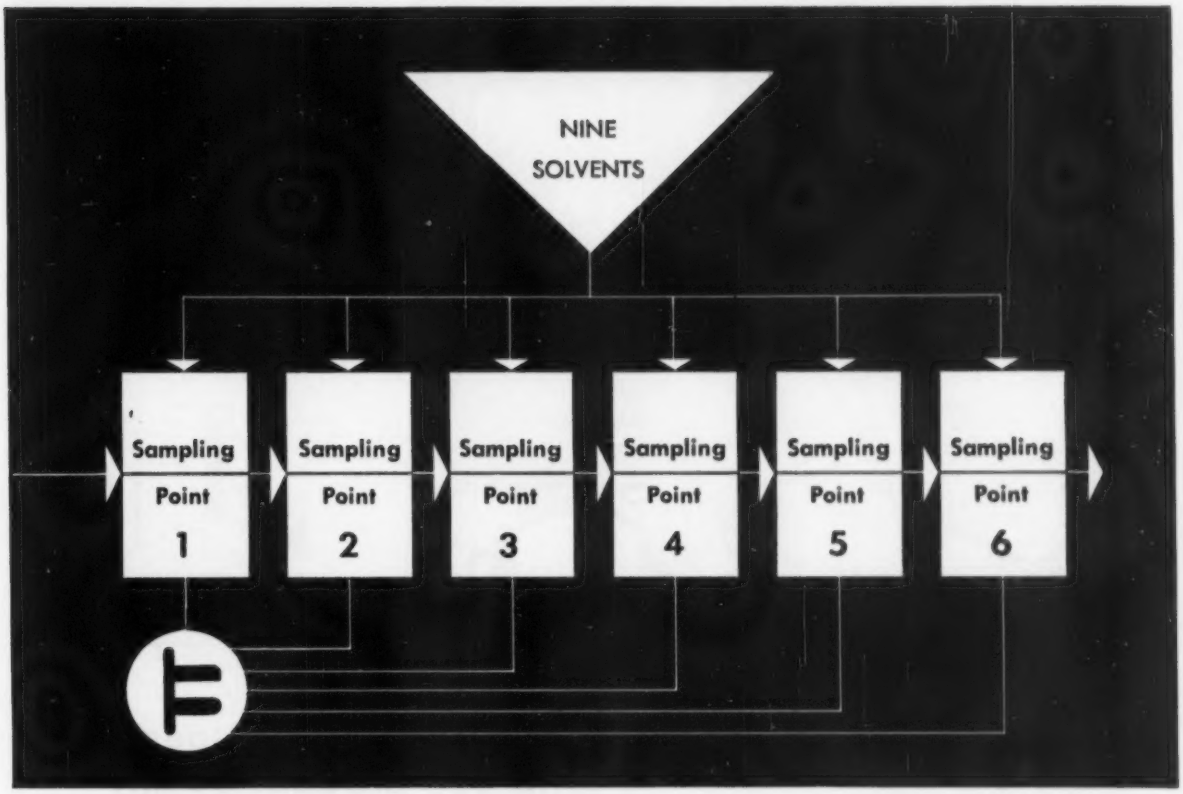
Phillips Announces Four New Products

Phillips Petroleum Company has announced the discovery of four new synthetic rubber-like materials with properties of commercial promise.

One of these, made from butadiene, may have possibilities as an economic alternate for natural rubber. It is 10 to 15 percent more resilient than regular GR-S synthetic and performs better at low temperatures.

A second form of the butadiene-based materials is a high-softening-point resin with potential applications in plastics and rubber. Neither of these uses styrene as one of its raw materials.

A third new product is based on isoprene as a starting material and is a synthetic counterpart to natural gutta percha or Balata, which is used when toughness is required. The company's scientists also are producing in the laboratory a synthetic



COMBUSTIBLE VAPORS KEPT BELOW EXPLOSIVE LIMITS WITH CONTINUOUS ANALYZERS . . .

Delays in detecting LEL reduced

In a process using nine solvents with lower explosive limits ranging from 1.3% to 13%, a P-E TRI-NON* Infrared Analyzer has the job of reporting vapor concentrations continuously so they can be kept below 80% of the explosive limit.

The TRI-NON analyzer is sensitized to give an equal and linear response for each of the nine solvents. This linearity allows summation of the various combinations at each station regardless of the actual vapor concentration of any one component. Only an infrared analyzer using a selective detector can be sensitized in this manner.

One TRI-NON analyzes samples from six different points in succession along the process line at a speed of 30 seconds per point. Each point is checked every 3 minutes – often enough in this particular application to detect any dangerous change in vapor concentration. (Instrument response times up to 3.4 seconds for 98% of final value are standard.) The TRI-NON is the only infrared analyzer with sufficient speed and stability to cover so many sampling points safely.

In combustible vapor analysis, whether the system contains one or a mixture of solvents, the TRI-NON provides the best zero and range stability available. It does not run into trouble when non-hydrocarbon materials are present in samples. Since it does not burn in order to analyze, deposits do not form in the detecting element and flash-back protection is unnecessary. Maintenance problems are kept to a minimum.

When you specify continuous analyzers for your process streams, P-E alone has a complete line of instruments to choose from. Or let us develop a complete analytical control system for you. Nowhere else can you get the combination of chemical engineering and instrument know-how that you'll find at P-E.

*T.M. The Perkin-Elmer Corp.

Perkin-Elmer
CORPORATION
Norwalk, Connecticut

P-E TRI-NON Analyzers are available in a wide range of models and prices to meet all types of continuous analytical problems. They are rugged and dependable, expressly designed for use in the varied environments of a processing plant or refinery. For quick and easy maintenance, instrument components can be tested right on stream — without disconnecting.

For more data on advertised products, use Readers' Service Cards, last page.

✔ **Stop entrainment losses**
✔ **Improve product quality**
✔ **Cut process costs**

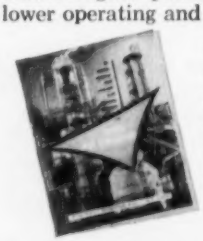
with METEX Hi-Thruput MIST ELIMINATORS

Collection and recovery of valuable liquid products — removal of liquid particles harmful to subsequent processes — reduced equipment maintenance and decreased air pollution . . . these are but a few of the possibilities METEX Hi-Thruput Mist Eliminators offer to alert process and project engineers.

METEX Hi-Thruput Mist Eliminators, installed in a process tower or vessel, effect sharp separation of entrained liquids within a wide range of vapor velocities. Pressure drop is negligible. Quality and yield are increased. High removal efficiency is maintained, even at extreme temperatures, due to free-drainage of impinged liquids. Liquid slugs cannot enter turbines or compressors. Coke formation is minimized and life expectancy is substantially increased even under adverse conditions.

Where solids may be formed in the mesh because of decomposition, polymerization, crystallization or freezing, METEX Hi-Thruput Mist Eliminators provide up to three times the service life of conventional units.

In any processing equipment or vessel where liquid entrainment is a contributing factor in design or operation, METEX Hi-Thruput Mist Eliminators assure higher production, better processing and lower operating and maintenance costs.



For complete information and specifications, write today for your copy of Bulletin ME-106, illustrating and describing METEX Mist Eliminators for all process equipment.

QUALITY METEX PRODUCTS

6-075

METAL TEXTILE CORPORATION
ROSELLE, NEW JERSEY

METAL TEXTILE CORP. OF CANADA, LTD., HAMILTON, ONTARIO
Representatives in principal cities throughout the world

What's Happening. . .

with the structure and properties of natural rubber. Two other companies which have announced products of this type are Firestone Tire and Rubber Company and Goodrich-Gulf Chemicals Company.

MEETINGS CALENDAR

MAY	
14–16	Petroleum Electric Power Association (Annual Convention), Hotel Robert Driscoll, Corpus Christi, Texas.
14–17	American Petroleum Institute, Division of Refining (Mid-Year Meeting), Sheraton-Mount Royal Hotel, Montreal, Canada.
14–17	American Society of Mechanical Engineers, Design Engineering Conference, Convention Hall, Philadelphia.
14–17	Design Engineering Show, Convention Hall, Philadelphia.
15–17	Industrial Waste Conference, Purdue University, Lafayette, Ind.
16–18	American Chemical Society, Division of Rubber Chemistry (Annual Meeting), Hotel Cleveland, Cleveland.
16–18	American Gas Association, (Chemical Engineering and Manufactured Gas Production Conference), Benjamin Franklin Hotel, Philadelphia.
24–25	Natural Gas and Petroleum Association of Canada, Sheraton-Brock Hotel, Niagara Falls, Ont.
27–June 1	American Society for Testing Materials, Conference on Mass Spectrometry, Netherlands, Plaza Hotel, Cincinnati.
28–30	Chemical Institute of Canada (Annual Conference and Exhibition), Mount Royal Hotel, Montreal, Quebec.
30–June 1,	Short Course on Gas Technology, Sponsored by Texas A&M College, Kingsville, Texas.
31–June 2	Interstate Oil Compact Commission, Statler-Hilton Hotel, Dallas.
JUNE	
3– 8	Society of Automotive Engineers (Summer Meeting), Chalfonte-Haddon Hall, Atlantic City, N.J.
4– 8	National Fire Prevention Association, (Annual Meeting) Statler Hotel, Boston, Mass.
7– 9	Manufacturing Chemists' Association (Annual Convention), Greenbrier Hotel, White Sulfur Springs, N.Y.
11–15	Technical Conference on Plastics, Sponsored by The Society of the Plastics Industry, Inc., Coliseum, New York.
17–21	American Society of Mechanical Engineers, Semi-Annual Meeting, Hotel Statler, Cleveland.
17–22	World Power Conference, Vienna, Austria.
17–22	American Society for Testing Materials (Annual Meeting and Apparatus Exhibit), Chalfonte-Haddon Hall, Atlantic City, N.J.
18–20	American Society of Heating and Air-Conditioning Engineers, Shoreham Hotel, Washington, D.C.
21–22	Western Petroleum Refiners Association, Regional Technical-Industrial Relations Meeting, Broadview Hotel, Wichita, Kans.
24–25	Canadian Gas Association, Manoir Richelieu, Murray Bay, Quebec.
25–29	American Institute of Electrical Engineers (Summer and Pacific General Meeting), San Francisco.
28–30	Rocky Mountain Oil and Gas Association, Mid-year Meeting, Utah Hotel, Salt Lake City.
JULY	
17–27	Massachusetts Institute of Technology, Special Summer Program on Recent Advances in Catalytic Polymerization, Cambridge, Mass.
18–21	Silver Bay Conference on Human Relations in Industry, Silver Bay, New York.
AUG.	
9–11	Denver Research Institute, Annual Symposium on Industrial Applications of X-Ray Analysis, Albany Hotel, Denver, Colorado.

Safe and Sure Packing for
HOT OIL CHARGE PUMPS
...ends packing blowouts and hot oil flashes

JOHN CRANE

High Temperature
METALLIC PACKING

STYLE 101-AL (Aluminum)

Available in spirals and die-formed rings to specific stuffing box sizes.

Made of continuous thin ribbons of soft aluminum foil, spirally wrapped, crinkled and folded about a small core of pure dry asbestos roving, and squared to desired size.

ADVANTAGES . . . Minimum wear on shaft sleeves . . . Easy adjustment by gland takeup . . . Operation at highest temperatures . . . Easy cutting of rings from stock spirals.

SERVICE . . . High Temperature centrifugal hot oil charge pumps . . . hot oil valves . . . Diphenyl valves . . . still necks.

"John Crane" High Temperature Metallic Packings have been developed, as a result of years of extensive research, to withstand temperatures as high as 750°F.—discharge pressures of over 800 lbs.—speeds of 3600 rpm or more.

These "John Crane" Packings have been in continuous use on heavy and light hot oil charge pumps for years without maintenance or attention. One user reports . . . "seven years of continuous service and still as dependable as the day it was installed."

For a truly dependable packing for hot oil charge pumps, specify "John Crane" Style 101-AL. For the right combination of "John Crane" Packings to meet your specific needs, consult with experienced Crane Packing Company field engineers.

Send for catalog giving detailed information on "John Crane" complete line of packings for all services. Crane Packing Co., 6420 Oakton St., Morton Grove, Ill., (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS

What's Happening . . .

. . . *Among Men* in the Industry

Harold W. Washburn, vice president and director of research for Consolidated Engineering Corporation in Pasadena, Calif., has received the $1000 Beckman Award in Chemical Instrumentation. He is principal inventor of the analytical mass spectrometer.

The prize is sponsored by Beckman Instruments, Inc. Its presentation to Dr. Washburn was made at the 129th national meeting of the American Chemical Society in Dallas.

Twenty-eight patents and 18 technical articles are attributed to Dr. Washburn, who has been working in mass spectrometric analysis since 1938. He directed construction of the first mass spectrometer for analytical work in 1940.

Dr. Washburn served with General Electric Company and Western Geophysical Company before joining Consolidated Engineering. He was made a vice president of that company in 1937. In addition, he taught at Massachusetts Institute of Technology and the University of California.

Robert C. Oliver has been named senior research engineer for The Fluor Corporation, Ltd., at its Whittier, Calif., laboratories. He formerly was with Union Oil Company of California at Wilmington.

Others receiving new appointments in the Fluor Research division were **Loren Miller** and **Donat B. Brice,** both named research chemical engineers, and **Paul H. Dutch,** named research chemist.

Miller formerly was with E. I. du Pont de Nemours & Company at its Jackson laboratory; Brice had been with Food Machinery & Chemical Corporation at San Jose, Calif., and Dutch was with U. S. Testing Laboratories in Los Angeles.

Noel F. Boyd, formerly assistant chief process engineer for Blaw-Knox Company, is one of three receiving promotions in the company's Chemical Plants division. He will direct the Process department as chief process engineer.

Boyd

Named as his assistant in charge of chemical process work was **William W. Lawrence,** and **Claude E. Durgee** was made assistant in charge of layout activities.

In the Chemical Plants division, Boyd has served as supervising process engineer in the design of chemical and process plants. He formerly was with Standard Oil Company (Indiana) engaged in process-design, pilot-plant and technical-service work.

Lawrence joined Blaw-Knox in 1945, and much of his work has been on Atomic Energy Commission projects. Durgee has been principal engineer in charge of preparing functional layouts and engineering designs on piping, instrumentation, electrical vessels, structural and mechanical.

W. H. Vaughan

W. H. Vaughan, manager of Tide Water Associated Oil Company's Gas Utilization department in Houston, has received the Hanlon Award.

The highest honor in the natural-gasoline industry and one of the ranking awards of the petroleum industry, the award was conferred on him at the 35th annual convention of the Natural Gasoline Association of America in Fort Worth.

Vaughan is the 20th recipient of the Hanlon Award which is conferred annually by NGAA for outstanding service to the natural-gasoline industry. Donor of the award is **E. I. Hanlon,** chairman of the board of the National Bank of Tulsa.

Presentation was by NGAA President **A. H. Weil,** with United Gas Pipe Line Company in Shreveport. The citation read in part:

"We are recognizing the results of this man's studies of high pressure, two-phase gas streams. His work, experimentation and original thinking in this field mark him as one of the earliest pioneers in finding a practical solution to the gas cycling problem.

"The success of his first plant, the forerunner of many similar plants to come, proved to other operators and to regulatory bodies that gas-condensate wells could be produced economically and thus, the cycling industry was born."

Vaughan joined Gulf Oil Corporation as a construction foreman, shortly after World War I, in which he served overseas. He became superintendent of Gulf's Natural Gas department in 1922, a position he held until 1931 when he was transferred to Houston as general superintendent of natural-gas and natural-gasoline operations.

He resigned two years later to do private research work, but joined Tide Water Associated Oil Company in 1935 to supervise its operations in gas-condensate fields. His experiments in the Cayuga field of central Texas led to his design and construction of the first cycling plant to obtain permission to operate from The Texas Railroad Commission.

Archie D. Gray, general counsel of Gulf Oil Corporation, has been appointed a member of the API's American Petroleum Industries committee. He succeeds **David Proctor,** executive vice president and a director of Gulf Oil, who resigned after serving with the committee more than 11 years.

Gray has been with Gulf since 1935, when he joined the Law Department at Houston. In 1947 he was appointed associate general attorney for Gulf and in 1953 was transferred to the general offices in Philadelphia. He was named general counsel early in 1956.

James P. Wiseman, president of Fluor Products Company, has been elected president of the Cooling Tower Institute for 1956. The outgoing president is **Neal B. LauBach,** of Hudson Engineering Corporation.

Other officers elected for 1956 terms are **Forrest B. Reed,** The Marley Company, vice president; **Karl E. Johnson,** J. E. Pritchard & Company of California, secretary, and **Denis E. O'Neil,** Foster Wheeler Corporation, treasurer.

Also serving on the executive board are **Paul R. Hoffmann,** Lilie-Hoffmann Cooling Towers, Inc., and **Ennis C. Smith,** Hudson Engineering Corporation.

Robert S. Holdsworth has joined the staff of National Research Corporation, as a group leader in the Petrochemical Research department. He will be engaged in research in polymerizing, a part of the program National Research is operating for Escambia Bay Chemical Corporation. Before joining the research company, Dr. Holdsworth was with U. S. Rubber Company's Naugatuck Chemical division.

A. W. Bass has been appointed manager of operations for The Atlantic Refining Company of Brazil. He was operations manager in the Foreign Marketing department at the company's headquarters in Philadelphia. He will be located at Rio de Janeiro.

George S. Bays has joined the staff of International Petroleum (Colombia), Ltd., as manufacturing manager. He formerly was with Humble Oil & Refining Company at its Baytown, Texas, refinery.

Dr. Bays joined Humble in 1936, starting in the Technical Service division and later becoming a section head. He was made assistant superintendent of the Bay-

Typical Mechanical Properties of Ni-Vee Bronzes

TYPE	A (lead free)			B (1% lead		C (5% lead)		D (10% lead)		E (20% lead)	
	As Cast	Tempered	Heat-Treated	As Cast	Tempered	As Cast	Tempered	As Cast	Tempered	As Cast	Tempered
Tensile Strength (thousand psi).....	50	65	85	45	60	40	50	35	40	25	30
Yield Strength (thousand psi).....	22	40	55	20	30	20	30	20	25	18	22
Elongation, % in 2".....	40	10	10	30	8	15	5	10	2	5	2
Brinell Hardness.....	85	130	180	80	120	80	130	80	110	70	80

Specifying is simple and systematic with 5 versatile Ni-Vee Bronzes

Now . . . designers and engineers can readily select a suitable bronze for any specific need . . . from only five Ni-Vee* bronzes.

"As Cast," these five Ni-Vee bronzes provide mechanical properties that surpass those of comparable G bronze, red brasses and leaded bearing bronzes. What's more, their superior properties can be still further elevated by simple heat-treatments.

Basically, each Ni-Vee bronze contains 5% nickel and 5% tin, from 0 up to 20% of lead. Tensile strength ranges from 25 to 85 thousand psi, and hardness from 70 to 180 Brinell.

Advantages

Just five of these Ni-Vee bronzes make it possible to standardize metal inventories, melting practices and shop operation . . . as well as specification . . . to meet many industrial uses for copper-base castings.

Each Ni-Vee bronze contains an optimum nickel content to raise levels of strength, hardness and toughness. In addition, this nickel content provides a high degree of corrosion resistance in the Ni-Vee bronzes. Negligible zinc content makes it free from dezincification. This spells resistance to stress-corrosion attack.

A versatile family

Copper-base alloys are ordinarily used for the three types of castings listed below. For each of these applications a Ni-Vee bronze provides particular advantages:

(1) **Constructional** castings – high strength
(2) **Pressure** castings – fine grain
(3) **Bearing** castings – resistance to wear and seizure

The simple family of five Ni-Vee bronzes actually replaces the confusing variety of miscellaneous bronzes. As a result, engineers and designers can now specify simply and systematically . . . specify Ni-Vee bronzes wherever possible. Parts cast in Ni-Vee bronze already serve *electrical, power, steel, petroleum, chemical, automotive, aircraft, railroad and other industries.*

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Learn how the Ni-Vee bronzes can simplify your specification work, improve product performance. Send for a copy of *"Engineering Properties and Applications of Ni-Vee Bronzes."* It contains useful information like that given in the table above: tables of composition, charts on deformation, friction, fatigue, elevated temperature service, electrical resistivity, wear and other engineering data. *Write for it now.*

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For more data on advertised products, use Readers' Service Cards, last page.

how much does heater downtime cost?

A 36,000 B/D petroleum refining unit using a 100 million Btu heater upgrades the value of its crude charge roughly $25,000 per stream day. If the heater comes down for any reason only 10 days a year, a loss of a quarter million dollars is chalked up. A gain of 30 operating days in the year can mean a realization of 10% on capital investment which, in a multi-million dollar plant, is a considerable sum.

Downtime is expensive. The purchaser of a heater must as a result look beyond his initial cost to the long pull. For the long pull, Lummus oil heaters have consistently exhibited great durability while operating efficiently and with an absolute minimum of days lost to maintenance work.

The major refiners prefer Lummus heaters for this reason. In the last 25 years, the dollar value of Lummus furnaces purchased has exceeded that of any other company in the world. So—when you consider a new refinery or a new unit—assure good operation and maximum profit throughout the life of your plant.

Consult with us on design, engineering and construction of your heater installation.

The Lummus Company, Oil Heater Division, 385 Madison Avenue, New York 17, N. Y. Branch offices in Chicago, Houston, Montreal, London, Paris, The Hague, Caracas.

LUMMUS

OIL HEATER DIVISION

town Ordnance Works, which Humble operated for the government, in 1943.

He served in Humble's Houston office on a training assignment, and in 1949 returned to Baytown where he held training assignments in the Coordinating and Process departments until he went with International Petroleum.

Harold R. Snow, vice president of manufacturing for American Oil Company, has been elected to the board. He has been with the company and the parent Standard Oil Company (Indiana) more than 30 years.

Glynn R. Kruger has been appointed chief process engineer for Procon, Inc. He was with Union Tank & Supply Company and Delta Engineering Corporation, both in Houston. Prior to that he was in the Process and Product Development division of The Pure Oil Company's research laboratories.

Kruger

Charles M. Harless, assistant superintendent of The Texas Company's works at Port Neches, Texas, has been appointed superintendent. He succeeds **R. C. Schorlemmer** who died.

J. T. Yardley, Jr., formerly foreman of crude stills, was promoted to succeed Harless as assistant superintendent.

Harless joined Texaco in 1928 as an engineer at the Port Arthur, Texas, works. The following year, he was transferred to Port Neches. He was made chief engineer in 1941 and became assistant superintendent in 1944.

Yardley has been with the company since 1938 and at Port Neches since 1948.

Oliver W. Weinkauff, an associate director of research in Monsanto Chemical Company's Organic Chemicals division, has been appointed to a newly-created position of director of technology.

Also named to a new position in the division's Research department is **Harry W. Faust,** an assistant director of research, who was named assistant to the director of research. He will coordinate the department's research in petrochemicals with related efforts both within and outside the company.

Dr. Weinkauff will devote his attention to technical problems within the division and to liaison with other Monsanto divisions.

Ralph H. Munch, a research section leader, was promoted to assistant director of research. He will be assigned to physical and analytical chemistry.

K. E. Kingman has been elected to the board of Union Oil Company of California. He is the company's vice president for manufacturing.

Robert E. Maescher has been appointed superintendent of the General Petroleum Corporation refinery at Tor-

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WELDOLETS

FOR ASSURED STRENGTH
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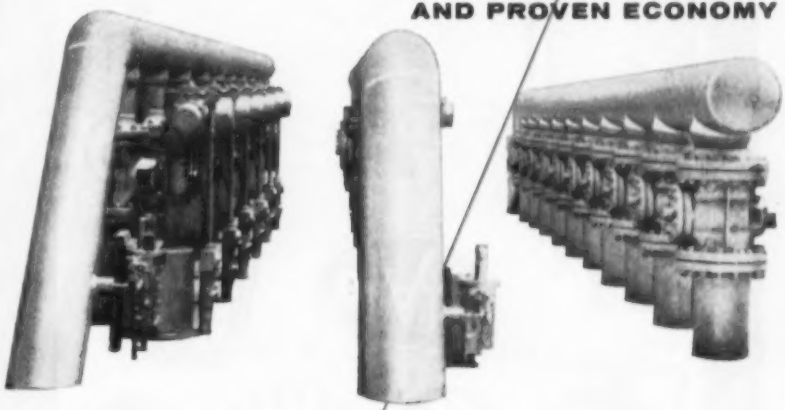

Are you effecting this economy for your company? Neat and uniform appearance is evident in code constructed weldolet headers in this crude oil pipeline terminal. The money saved is in the bank and does not appear in this picture. If you are not using the weldolet method of cutting piping costs, write today for information.

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WELDING FITTINGS DIVISION
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• Peabody Direct Fired Air Heaters are engineered designed and built to meet individual job specifications in the petroleum refining industry.

They are available in a complete range of pressures and firing rates from 1,000,000 BTU/hr upward.

For complete information on these custom engineered Air Heaters, write for Bulletin 600A.

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Men in the Industry . . .

rance, Calif. Except for two years spent at the company's Vernon, Calif., laboratories, Maescher has been assigned to the Torrance refinery since he joined the company in 1938.

W. W. White has been elected vice president of Esso Research and Engineering Company, after completing an assignment as staff director of the Petroleum Logistics division in the Office of the Assistant Secretary of Defense (Supply and Logistics).

Johnson

Lilley

G. Clifford Johnson has been appointed manager of supervisory training for Sun Oil Company's Manufacturing department. **John E. Lilley** was named to succeed Johnson as superintendent of the Mechanical department at Marcus Hook.

In his newly-created post, Johnson will be responsible for supervisory training and executive development in the Manufacturing department.

Johnson joined Sun at Marcus Hook in 1929. He became assistant superintendent for maintenance in 1943; superintendent of construction and maintenance in 1946, and superintendent of the Mechanical department in 1949.

Lilley started with the company in 1932. He held a number of construction positions before he was named chief construction engineer in 1946. He had been chief engineer in the Mechanical department for the past three years.

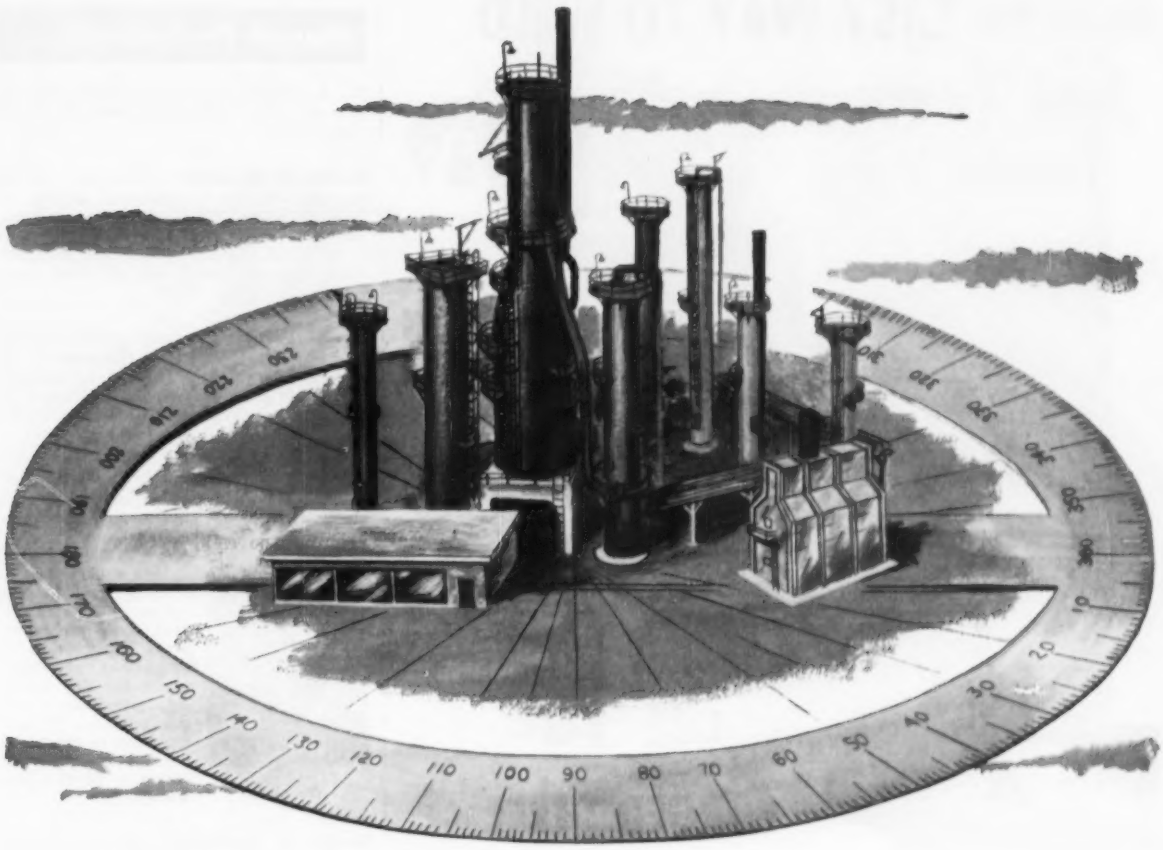
Walter A. Arnold, formerly assistant refining coordinator in the New York headquarters of Standard-Vacuum Oil Company, has been named managing director of Standard-Vacuum Refining Company of South Africa, Pty., Ltd., at Durban. **J. B. Hanna,** whom he succeeds, has returned to the U. S. for reassignment.

Arnold joined Stanvac in 1946 following ten years with refineries in New Jersey and Louisiana. He served two periods at the company's Sungei Gerong refinery near Palembang in Sumatra, Indonesia, first as assistant refinery manager and then as manager.

Returning to Sumatra in 1952 after a year in the New York office, he was appointed assistant operations manager for Stanvac's subsidiary in Indonesia. He assumed his duties as assistant refining coordinator in New York in 1953.

M. W. Bretz has been named plant superintendent of Stanolind Oil and Gas Company's Three Bar gasoline plant near Kermit, Texas. Formerly plant superintendent at the company's Salt Creek gasoline plant near Midwest, Wyo., he replaces

For more data on advertised products, use Readers' Service Cards, last page.



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Here's the **EASY WAY TO WELD**

Small Diameter Pressure Piping

USE W-S FORGED STEEL SOCKET-WELDING FITTINGS

In addition to providing high strength and toughness, W-S Forged Steel Socket-Welding Fittings are also easy to install. Deep sockets support and align the pipe for welding . . . eliminating the need for tack welding or special fixtures. No back-up ring is needed either. The fillet-weld is completely outside the pipe. Welding icicles just can't form inside the pipe. The result is a clean, tight welded joint that will readily resist high pressures and the stresses of shock and vibration. What's more, installation costs are lower.

W-S Socket-Welding Fittings are available in sizes ⅛" to 4" for schedule 40, 80, 160 and double-extra heavy pipe in carbon steel, stainless steels and alloy steels.

For complete information on the installation and operation advantages of W-S Forged Steel Socket-Welding Fittings, send today for Bulletin A-3-56.

W-S FITTINGS DIVISION

H. K. PORTER COMPANY, INC.
Roselle, New Jersey

Men in the Industry . . .

G. A. Ayling, who was transferred to Wyoming. Bretz has been with Stanolind since 1940.

Robert S. Kestner will become a group engineer in the Construction section of The Standard Oil Company (Ohio). Formerly with Sohio Pipe Line Company in St. Louis, he will be stationed in Cleveland. Kestner joined the affiliated pipeline company in 1947.

A. A. White has been named general counsel for Texas Gas Corporation in Houston. To take the position, he resigned as dean of the University of Houston College of Law. White had been dean of the law college since it was founded.

H. L. Watchous has been named construction manager of Tellepsen Petro-Chem Constructors, a division of Tellepsen Construction Company.

Watchous

With the Houston concern since 1944, Watchous has supervised construction of a number of major plants for the chemical, petroleum and gas industries. He also has been in charge of building industrial plants in Mexico and Venezuela.

Serge B. Jureney, assistant to the chairman of Continental Oil Company, has been made assistant to the president and chief economist. He will continue to make his headquarters in New York.

Louis H. Butterworth, assistant manager of the Standard Oil Company (Indiana) refinery at Wood River, Ill., has been named to succeed **Harry E. Cotton** as manager at Wood River. Cotton will retire.

Butterworth joined the company's Research department at Whiting, Ind., in 1937, and he was transferred to the Manufacturing department there in 1942 as assistant general foreman.

In 1947 he was promoted to assistant general superintendent of the Casper, Wyo., refinery, and five years later he was moved to the general office in Chicago. He returned to Casper as general superintendent in 1953, and was made assistant manager at Wood River early this year.

Cotton became manager of the Wood River refinery in 1953. He started with Midwest Refining Company at Casper in 1919, and the operations of this refinery were taken over by Standard Oil in 1921.

David N. McClanahan and **Edwin D. Redding** have been elected vice presidents of Wyatt C. Hedrick Engineering Corporation. McClanahan will serve the Houston concern as vice president in charge of process and chemical engineering; Redding will be vice president in charge of project and design engineering.

Jay H. Forrester will be president of a new chemical company to be formed by the consolidation of three Standard Oil

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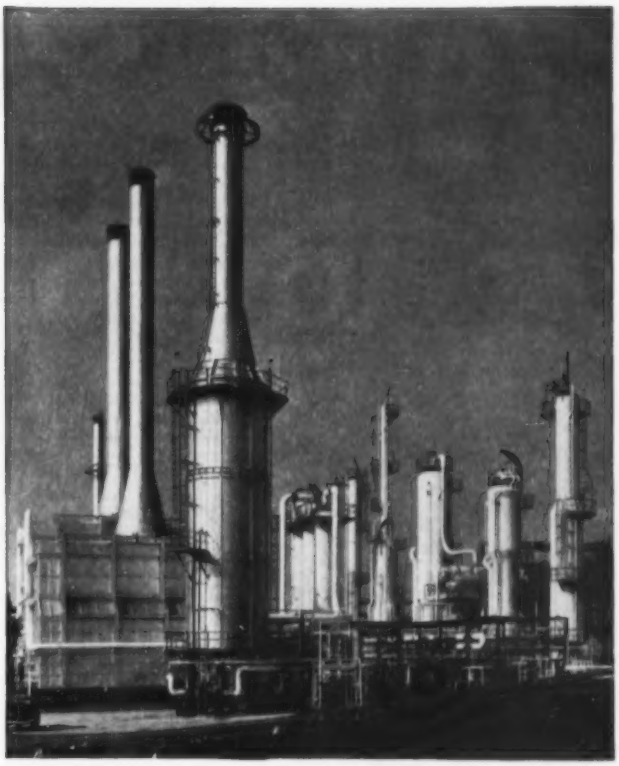
INTERESTED IN UNIFINING* FOR DESULFURIZATION AND UPGRADING



• Unifining Unit
Union Oil Company of California refinery
Oleum, California

UNIFINING should be of particular interest to all operators of catalytic reformers which produce by-product hydrogen.

• Harshaw is the exclusive producer of the Union Oil Company of California cobalt-molybdate catalyst used in the recently announced "Unifining" desulfurization and upgrading process. This rugged, commercially proven catalyst is supplied in the form of cylindrical tablets conforming to rigid physical and chemical specifications established by Harshaw and Union Oil Company of California. Stability at high temperatures permits repeated regenerations if and when necessary.

Please contact Harshaw for further information on this catalyst.

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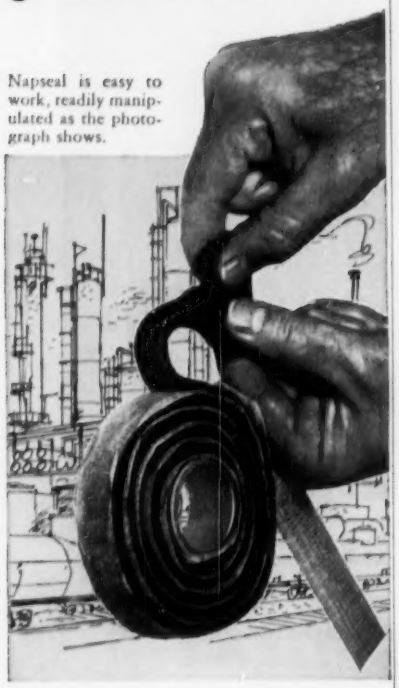
sealing compound resists gasoline and oil...

Napseal is easy to work, readily manipulated as the photograph shows.



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Napseal is the compound for those difficult sealing jobs where exposure to oils and fuels (including aviation gasoline) is encountered. Highly adhesive, it holds a tight seal, remaining permanently plastic in the presence of petroleum derivatives. Napseal retains its water tightness, will not dry out in service.

Napseal is easy to work and remains workable over a wide temperature range. It will not corrode metals or cause the deterioration of common substances in contact. Neither will it stain.

Napseal is handy for emergencies and other sealing needs. It requires no mixing, comes ready to use in beads, ribbons and 3" diameter pugs. Data sheet EL-64A gives more information. Write Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit, Ontario.

JM

Johns-Manville
SEALING COMPOUNDS

Men in the Industry . . .

Company (Indiana) chemical subsidiaries late this year.

Forrester is now manager of research for Standard. He will be succeeded in this position by **Philip C. White**, manager of research and development for American Oil Company at Texas City, Texas.

Joseph K. Roberts, a member of the board, will have general responsibility for the company's over-all activities in the petrochemical field. He will continue as general manager of research and development for Standard.

The new chemical concern will headquarter in Chicago. Its name has not been selected. The chemical consolidation is part of a functional reorganization of nine Standard Oil subsidiaries announced earlier.

The three chemical subsidiaries to be merged are Indoil Chemical Company, Pan American Chemicals Corporation and Hidalgo Chemical Company.

G. A. Ayling has been named plant superintendent of Stanolind Oil and Gas Company's Salt Creek gasoline plant at Midwest, Wyo. Formerly superintendent of Stanolind's gasoline plant near Kermit, Texas, he replaces **M. W. Bretz**, who is being transferred to West Texas.

Ayling started with Stanolind in 1947 as foreman at its gasoline plant near Sundown, Texas. Later he was foreman at two other company plants, and after serving as senior mechanical engineer in the general offices at Tulsa, he was made plant superintendent at Midwest. He took over that post in 1952.

L. A. Woodward has been elected administrative vice president of Kerr-McGee Oil Industries, Inc. He was president of Mid-West Refineries, Inc.

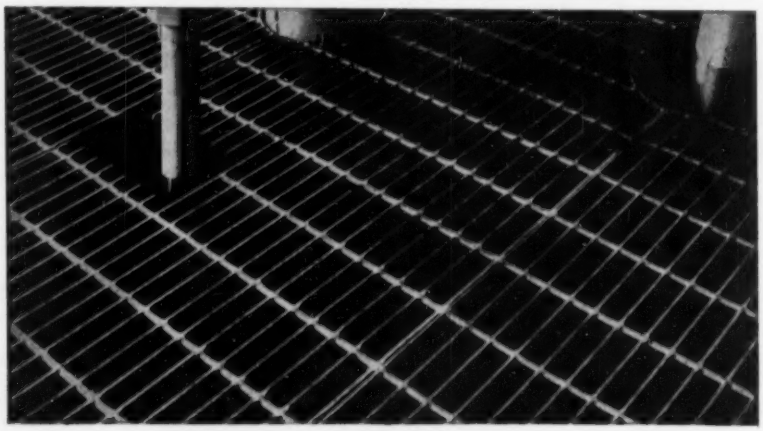
Harrison C. Givens, Jr., former manager of the Manufacturing department of Celanese Corporation of America's Textile division, has been made vice president-operations for Celanese International Corporation. He will be responsible for continuing liaison between the company and Canadian Chemical & Cellulose Company, Ltd., its Canadian affiliate.

Givens

Givens joined Celanese in 1933 at its Cumberland, Md., plant. He was made plant manager at Cumberland in 1949, serving in that capacity until 1952 when he was named manager of plant operations for the newly-created Textile division. In 1955, he became manager of the division's Manufacturing department.

Edwin G. Halter, a Cleveland attorney, has been elected to the board of Arthur G. McKee & Company. He is director of a number of companies headquartered in Cleveland.

P. Craig Livesay, assistant manager of the Standard Oil Company (Indiana) refinery at Sugar Creek, Mo., has been appointed manager of the company's Neo-



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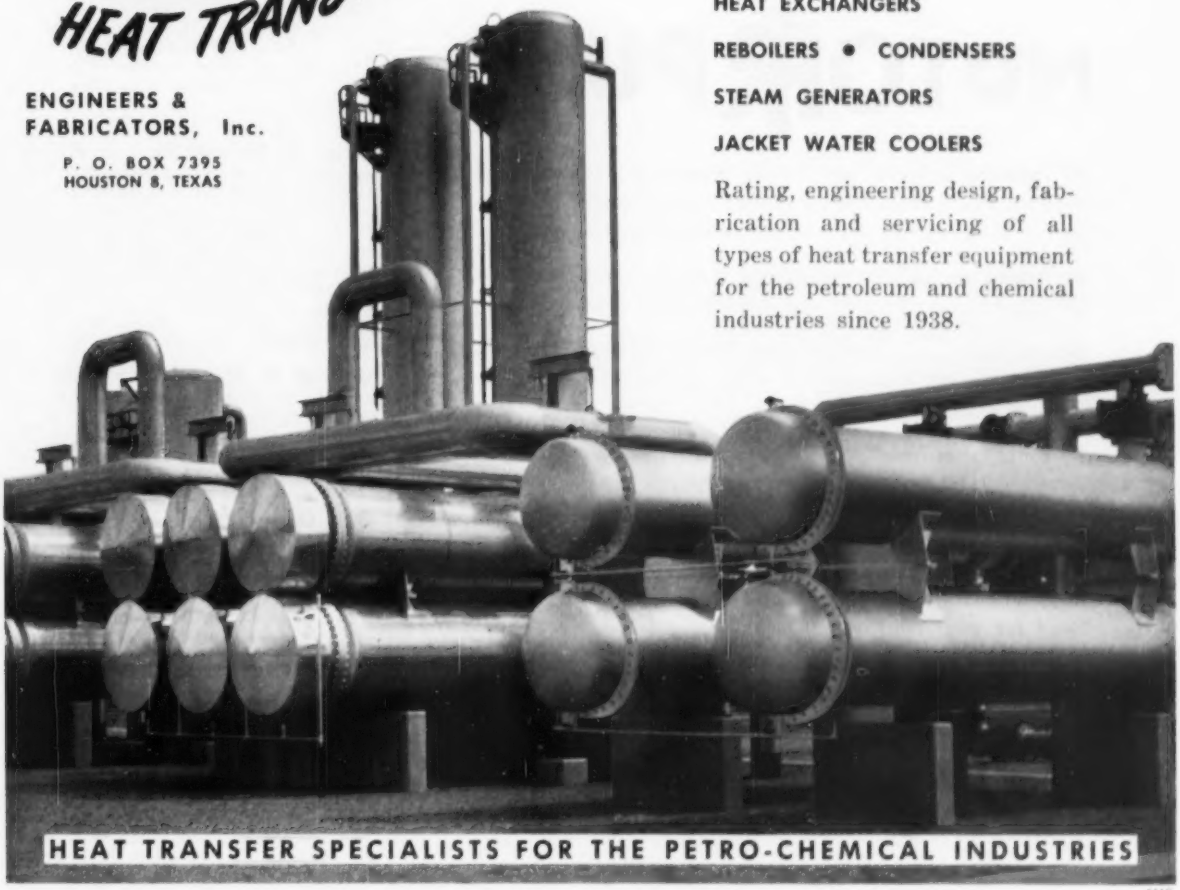

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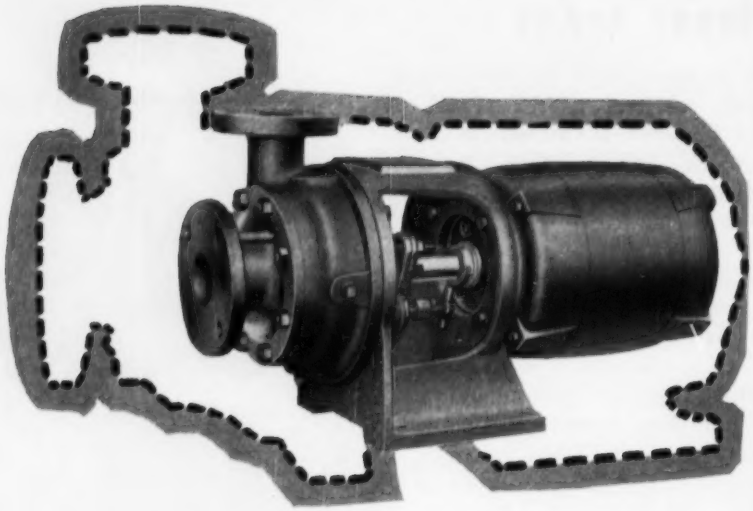

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By reducing original cost. Many plant operators say yes, because liquid handling operations can generally be done by I-R Motorpumps of lower horsepower than other pumps.

By saving on weight and space. Both, probably—because Motorpumps are so compact and efficiently designed.

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Men in the Industry . . .

desha, Kansas, refinery. He succeeds **Edward A. Metcalf** who will retire.

Livesay joined Standard in 1937 as an engineer at Whiting, Ind., later serving there as foreman and general foreman of the Heavy Oils division, superintendent of the Projects division and assistant general superintendent.

In 1952 he was assigned to the general office in Chicago, and two years later he was advanced to general superintendent of the Sugar Creek refinery. He became assistant manager earlier this year.

Metcalf had been manager at Neodesha since 1942. He started with the company in 1913.

Thomas W. Burtt has been appointed vice president in charge of engineering and construction for Holmes & Narver, Inc. His duties with the Los Angeles concern will include direction of all the company's engineering and construction projects. The company is a firm of engineers and constructors handling industrial and petrochemical projects.

Burtt

Burtt was with Standard Oil Company 25 years, handling engineering and construction assignments, both in the U. S. and abroad. He also was chief engineer at Standard's El Segundo, Calif., refinery. He joined Holmes & Narver in 1952, was appointed director of engineering and later became a member of the board.

Claud B. Barrett has been elected a director of The Texas Company. He is vice president for the company at Houston.

Barrett joined Texaco in 1927 and has held increasingly important positions. He was elected vice president in charge of sales in 1953, and became vice president at Houston in 1955.

Deaths—

George H. Shaw, vice president and director of Cities Service Oil Company, died of a heart attack April 24 at the company's annual meeting in Dover, Del. He had been with the company since 1933.

G. F. Gephart, comptroller of Standard Oil Company of California, died April 24 in San Francisco, after undergoing major surgery. He was 57-years-old.

Gephart joined Pacific Gasoline Company in 1922, and this company became part of the Standard organization in 1926. He became assistant comptroller in 1943 and was named comptroller the following year.

William Raymond Allen, formerly head of Sinclair Refining Company's Chicago Central District Legal department, died April 8 in Ocean Springs, Miss., following a long illness. He would have been 79 years old April 16. Allen, who joined the company's legal staff in 1919, retired from active service in 1943.

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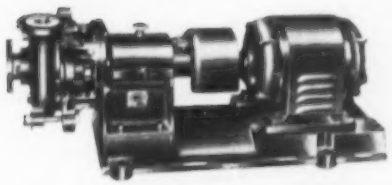

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The valve illustrated here is the answer. Like the parent valve, this new valve has safety and strength to spare . . . guaranteed for working pressures up to 10,000 psi . . . equally efficient and effective in any lower pressure range.

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- Packing, special Marsh "Marpak" moulded ring.
- Fine stem threads for strength and precision throttling.
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- Bodies marked in accordance with MSS regulations.

Maximum Working Pressure 10,000 P.S.I.

Water, oil, gas or corrosive fluids not injurious to 416 stainless steel.

The new all stainless valves (Series 1924) includes globe and angle patterns with double female connections in sizes ⅛", ¼", ⅜", ½", ¾", 1"; also globe and angle valves with male inlet and female outlet in sizes ¼" and ½".

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What Suppliers Are Doing . . .

Thurston Maher Dayton Oram Walker Duke Scatchard Stempf Hornaday

George H. Thurston, consulting metallurgist and manufacturers' representative, has been picked to handle sales and service for **The Duraloy Company** in all of California north of Los Angeles. He headquarters in Orinda, Calif.

John F. Maher has been elected a director of **Thermal Research & Engineering Corporation.** He is president of Oil Center Tool Company, which recently purchased considerable interest in the Thermal concern.

Michael S. Dayton has been named sales manager for Arga division of **Beckman Instruments, Inc.** He will be responsible for sales promotion, planning and coordination with field representatives. The company is a South Pasadena, Calif., firm.

Dan W. Oram, former head of the Market Development division of Kerrigan Iron Works, Inc., has been named executive director of sales for **Klemp Metal Grating Corporation.**

Owen H. Walker is the new field representative for the Houston-Beaumont area served by **Orbit Valve Company.** Walker, who was a sales supervisor with Gulf Oil Corporation, will headquarter in Houston.

Jack L. Duke has joined the staff of **Tod Pazdral Pipeline Specialties** as sales and service engineer in South Texas, south Louisiana and south Mississippi. He is a professional engineer in petroleum and natural-gas engineering.

Thomas Scatchard has been named plant manager for Berkeley division of **Beckman Instruments, Inc.** He was plant manager of assembly for Marchant Calculators, Inc., an Emeryville, Calif., concern.

C. R. Stempf has been made manager of a newly-created Standard Products section of **Worthington Corporation's** Export department. He was the corporation's special representative in Spain. He is a registered engineer in Massachusetts and the District of Columbia.

George F. Hornaday has been appointed assistant manager of process sales for **Houdry Process Corporation.** With the company since 1940, he has held a number of administrative and supervisory posts connected with Houdry's research and development of catalytic cracking and reforming.

Dobbins Keilman Davis Barnes Watkins Venable

William E. Dobbins has been made Central Regional sales manager for **Clark Bros. Company.** He will coordinate activities of the Houston, Tulsa and Chicago offices, headquartering in Houston. For the past 25 years, he has managed the Clark Bros. and Dresser Industries office in Washington, D. C. He also has been a special representative for Clark in the New York area.

C. J. Keilman has been appointed a vice president of **The Wm. Powell Company.** He will be in charge of sales in the New York area. Keilman has represented the company since 1946. He succeeds **Joseph L. Comer** in the New York territory. Comer recently died.

Raymond B. Davis has been appointed technical sales representative for **Wolverine Tube,** division of Calumet & Hecla, Inc., for its East-Central region. He will headquarter in Cleveland. He formerly was assigned to the company's general sales office in Detroit.

Roy M. Barnes, Jr., has been picked to fill the newly-created position of sales promotion manager in the Dyes and Chemicals division of **E. I. du Pont de Nemours and Company, Inc.** He formerly was in charge of sales promotion in the Eastern sales region of Du Pont's Petroleum Chemicals division.

M. Mark Watkins has been elected to the board of directors of **Walworth Company.** He is executive vice president and director of **Conoflow Corporation,** recently merged with Walworth. He also is a vice president and director of Remington Corporation. Before joining Conoflow in 1943, he was executive vice president of a Philadelphia bond and mortgage concern.

Tollie C. Venable has been appointed sales representative for **Lunkenheimer Company.** He will headquarter in Houston. Formerly with Corbett Corporation as a sales representative in Houston, he also has been connected with Crane Company.

Jones & Laughlin Supply Division has completed a new store and warehouse in St. Elmo, Ill. Manager of the new store is **Gerald Lee Berry;** the storemen are **Gerald H. Blair, Charles J. Gibson, Donald R. Gray** and **Billy J. Kelley,** while **C. W. Whitaker** is sales representative.

The International Nickel Company, Inc., has appointed **Albert P. Gagnebin** as manager and **Harold Larsen** as assistant manager of its Nickel Sales department.

Gagnebin succeeds **Ranson Cooper, Jr.,** who is retiring after 33 years with the company. Gagnebin had been assistant manager of the department since early 1955.

Larsen has been with International Nickel for 30 years, serving in various capacities in the Nickel Sales department.

Chicago-Wilcox Manufacturing Company has selected PenPower, Inc., to handle sales and services for its line of products in California. PenPower maintains a headquarters in Los Angeles and a district office in San Francisco.

The M. W. Kellogg Company has established a western regional office with headquarters in San Francisco. Named as manager of the new office was **William R. Dunn,** formerly Pacific Coast manager of Elliott Company. His assistant will be **Paul S. Jones,** a graduate of Cornell University.

Aluminum Company of America has named its research branch Alcoa Research Laboratories. Since its founding in 1918, "ARL" stood for Aluminum Research Laboratories.

With headquarters in New Kensington, Pa., the research organization has branches in Cleveland, East St. Louis and Massena, N. Y.

Stauffer Chemical Company will invest $1 million in expansion and modernization of its Niagara Falls, N. Y., plant. About $400,000 of this investment will be for additional facilities to manufacture 73-percent caustic acid. About $150,000 will be spent to increase the output of chlorinated solvents.

The company also plans to extend and

Suppliers . . .

improve several existing units which are producing chlorine, caustic soda, titanium tetrachloride, silicon tetrachloride and zirconium tetrachloride. Work on the additions is underway. They are due to be in operation by late summer.

Dean Brothers Pumps, Inc., has appointed **Robert D. Norton** as its New York manager of industrial sales. Before joining Dean Brothers, Norton was branch manager for five years of a pump and industrial-supply distributor at Charleston, W. Va., selling to chemical manufacturers.

General Electric Company has started a $6.8-million expansion of its Gas Turbine department facilities in Schenectady, N. Y.

The Fluor Corporation, Ltd., has scheduled a $500,000 building program to get underway at its main offices in Los Angeles. Three precast, tilt-up concrete buildings to house an additional 180 engineers and draftsmen will highlight the program.

Other facilities to be used in the expansion will include a $72,000 employe cafeteria, a $51,000 file-and-supply building and a $58,600 electrical center for the entire 27-acre plant area.

Fluor previously announced plans for the addition of a new $300,000 engineering and office building at its Mid-Continent division headquarters in Houston. Completion of this new building, which will add space for about 120 engineers, draftsmen and office personnel, is scheduled for September 1956.

Gates Engineering Company has appointed **Harry C. Burger** as vice president of operations. For the past eight years, Burger has been vice president and factory manager for Acme-Hamilton Manufacturing Corporation in Trenton, N. J.

Burger

His other experience in the rubber industry includes several years of production supervision with Electric Hose and Rubber Company in Wilmington and The B. F. Goodrich Company in Akron.

Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation has reassigned 11 of its salesmen. The following new assignments were made:

E. C. Biglow, Jr., to the Cleveland district; J. F. Brockman to the Boston district; R. F. Gildehaus to Philadelphia; P. G. Horecka to Newark; D. M. Neilson, New York; J. E. Nimz, San Francisco; C. D. Preston, New York; T. L. Proctor, Albany; W. R. Robertson, Newark; H. L. Smith, Houston, and F. N. Wright to the Newark district.

Beckman Industries, Inc., the first U. S. company to put up a manufacturing plant in Munich, Germany, has acquired the site for a new building which will cost $300,000, accommodate 400 employes and facilitate the company's operations in Western Europe. Construction will start immediately, with completion scheduled for October 1956.

ALCO Products, Inc., has appointed **Thomas L. Ward** manager of its plant at Dunkirk, N. Y. He succeeds **W. L. Larson** who retired.

Ward has been with the company since 1937. He joined the company in New York as assistant chief estimater and later worked as assistant chief engineer. In 1953 he was moved to Dunkirk as executive engineer and a year later was made marketing manager of the plant. He was named manager of manufacturing services in 1955.

National Can Corporation has appointed **Folke W. Anderson** as manager of its Chicago plant. Anderson had been superintendent at the plant almost ten years before he was promoted to assistant manager in April 1955.

The Texas Company has named **George E. Garland** as manager of its recently-established Petrochemical Sales division. The division, part of the Domestic Sales department, is responsible for market development and sales of Texaco-produced petrochemicals in the U. S.

Garland has been in the chemical and petrochemical sales field 22 years. Before joining Texaco, he was a consultant. From 1934 through 1944 he was with the Bar-

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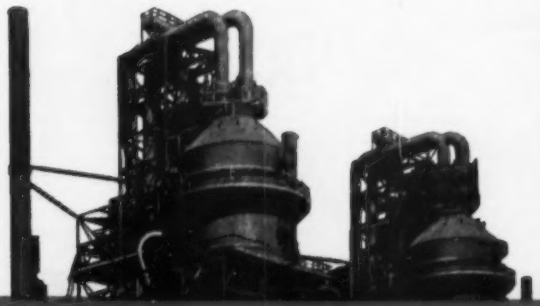

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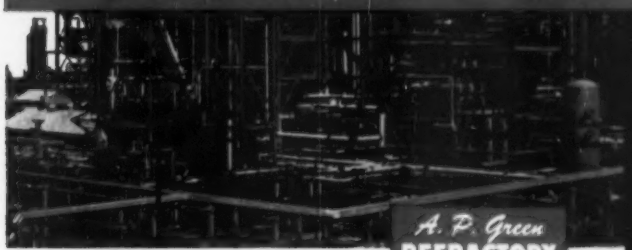

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rett division of Allied Chemical and Dye Corporation. Later he was with Shell Chemical Corporation.

Graver Tank & Manufacturing Company, Inc., has promoted **Leonard J. Cogan** to sales manager. Cogan, who will be headquartered in the company's Chicago office, will have charge of all company sales, except those handled by the Mid-Continent division, Graver Construction Company, Inc., and Graver Water Conditioning Company. He previously was assistant manager of Eastern sales headquartered in Philadalphia.

Cogan

Sorensen & Company has made a merger in Switzerland of its European subsidiary, Sorensen, Ltd., with Applied Research and Development, Ltd. Both concerns were in Zurich. The newly-formed company will be known as Sorensen-Allied Research and Development, Ltd.

Franz Roth, Allied president, will be sales and finance executive of the new company. **Paul Corbat** will direct research, technological and production activities. He was a director of Sorensen, Ltd.

U. S. Steel Corporation has appointed a number of new field representatives for its Oil Well Supply division. They were assigned to the following locations:

- **Jack T. Cline,** Lindsay, Okla.
- **Vernon W. Brazelton,** McCamey, Texas.
- **Luther C. Whalin,** Sundown, Texas.
- **M. L. Childress,** Carmi, Ill.

Named as store manager at Pauls Valley, Okla., was **Charles O. Damron, Jr.,** formerly a field representative at Lindsay, Okla. And **Donald E. Kyle** was promoted to district representative at Gainesville, Texas.

Union Asbestos & Rubber Company has promoted **John F. Corcoran** to general manager of its Equipment Steel Products, Equipment Specialties, Coldmobile and Hand Brake division. And **Emil T. Johnson** has been named general manager of the Fibrous Products division.

Both vice presidents, they will have full charge over the activities of the divisions they head.

Corcoran and Johnson joined the company in 1952 and 1947 respectively. Corcoran had been vice president in charge of sales, while Johnson was in charge of production and engineering activities.

Burgess-Manning Company has appointed five new representatives of its Penn Industrial Instruments division.

Firms which will handle sales of control and measuring equipment are E. R. Parkhurst Company, a Los Angeles concern covering southern California and Arizona, and A. J. Kroog Company, headquartered in Atlanta, which will be responsible for

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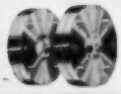

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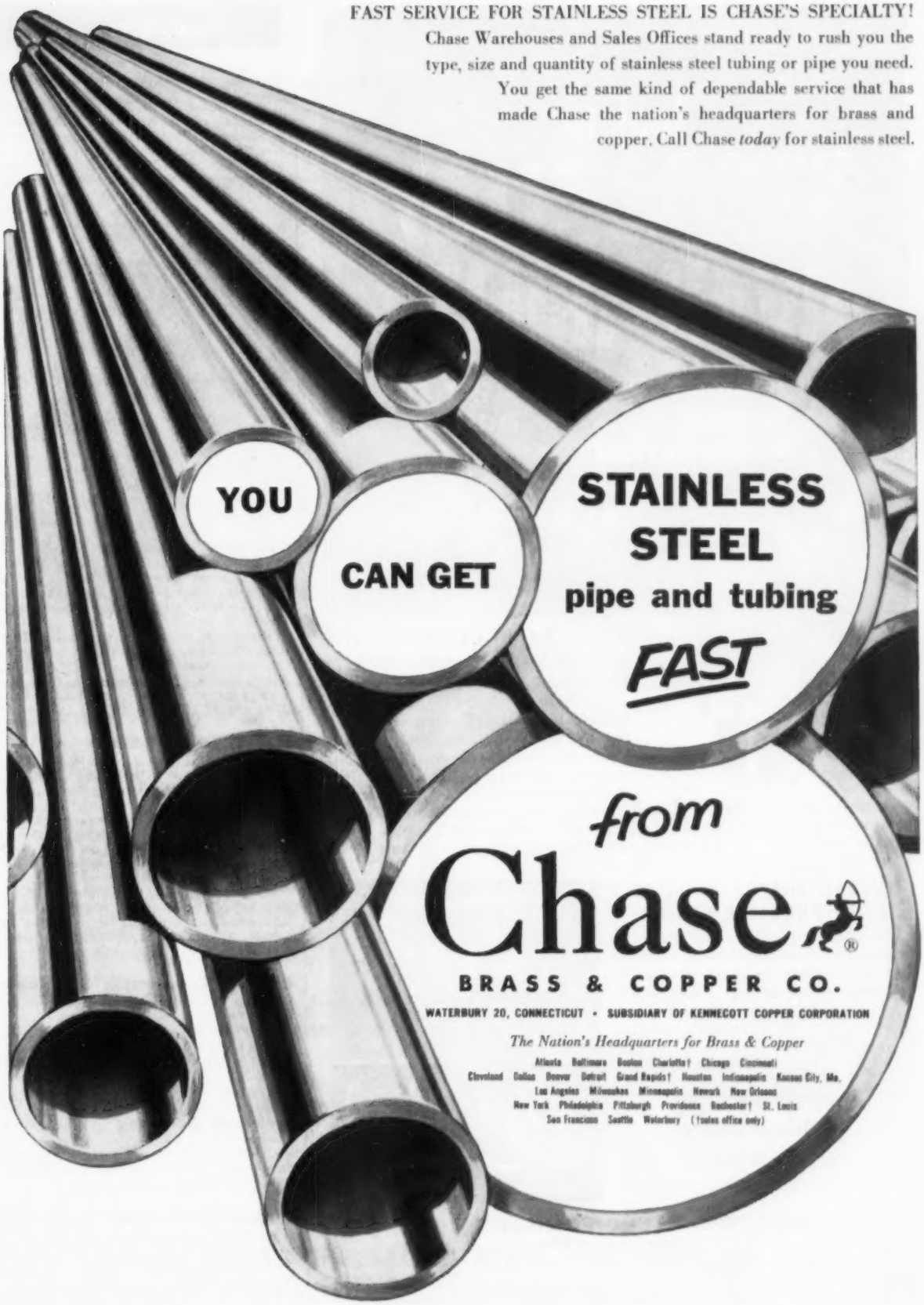
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Georgia, Alabama and North and South Carolina.

Representatives for control and flow instruments are M. S. Jacobs & Associates, of Carnegie, Pa., and Buffalo, given western New York, western Pennsylvania and West Virginia; Williams Equipment Company, in New Orleans, which has Louisiana and lower Mississippi, and T. I. Equipment Company, a Cleveland concern serving northern and eastern Ohio.

Pacific Pumps, Inc., has appointed **J. W. McCormick** as assistant sales manager for its Centrifugal Pump division. McCormick, who was Pacific's New York district manager, has been with the company since 1941.

McCormick

W. S. Eadie, formerly sales engineer in the company's New York and Chicago offices, was named New York district manager to succeed McCormick.

Laclede-Christy Division, H. K. Porter Company, Inc., has **B. B. Lanier, Jr.,** in charge of its export sales. At the company's general offices in St. Louis, he will supervise sales to all export territories.

Previously, Lanier was manager and assistant manager of American Express Company banking offices in Germany, Australia and Brazil. Before that he was with Yangtze Trading Corporation, handling export accounts.

T. I. W. Western, Ltd., is a new company formed by Toronto Iron Works, Ltd., and The Canadian Kellogg Company, Ltd., as part of a program to increase the companies' fabricating services.

The new company will incorporate the former Kellogg manufacturing shops at Edmonton, Alba. Toronto Iron Works will service its western customers through the new company.

All fabricating services introduced by Kellogg will be continued and the present Edmonton facilities will be expanded to permit the fabrication of additional products for Toronto Iron customers.

Catalytic Construction Company has been presented an award of merit in recognition of its safety record on Atomic Energy Commission projects at Oak Ridge, Tenn. The award, made by AEC, was for the company's record over a two-year period, "in recognition of 1,319,102 employe-hours without a disabling accident."

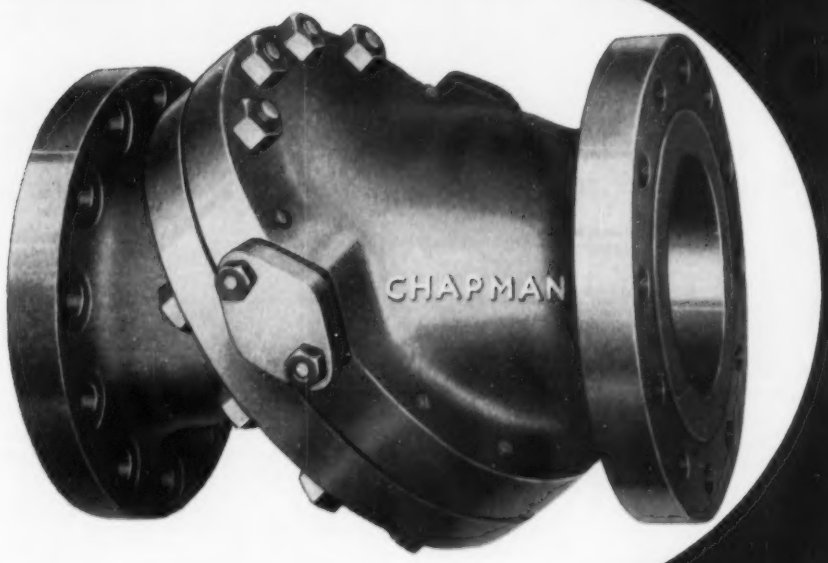
Walworth Company has elected a new member of its board of directors. He is **Carl Frederick Floe,** professor of metallurgy and assistant provost at Massachusetts Institute of Technology.

Baldwin-Hill Company has appointed **J. L. Mohun** as general sales manager for its Industrial Insulation division. He will be in the general sales office at Trenton, New Jersey.

With the company five years, Mohun

For more data on advertised products, use Readers' Service Cards, last page.

CHAPMAN TILTING DISC CHECK VALVE

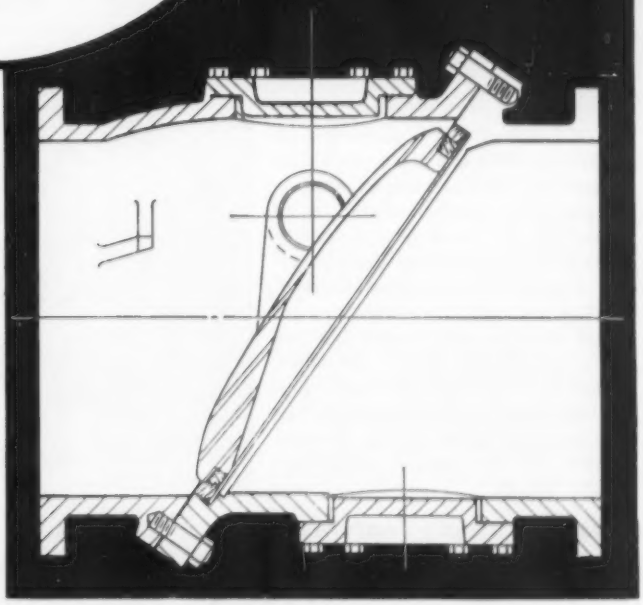


the Valve with the Right Idea!

Here is a cross section of top check valve performance at lowest cost. It's the idea in back of Chapman's Tilting Disc Check Valve . . . the valve that's designed to go with the flow.

When the flow is on, specially designed "airfoil" disc balances perfectly in open position. Fluid holds it tightly against stops. There's no vibration . . . no flutter. It's quiet. And note the design. Ample room is allowed around disc to assure low flow resistance.

When the flow is reversed, disc drops surely, quietly, *tightly* on special beveled seat. There's no banging, no slamming, no scraping or wearing of disc and seat faces, no damage to piping joints or the valve itself. It's as simple as that. It's as *sound* as that. It has the right idea.

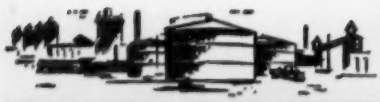


Complete information on these rugged, quiet, long life check valves is highlighted in our Catalog 30-A. Whether you want iron or steel construction . . . whether you handle fluids or gases under a wide range of pressures . . . this catalog gives you all the facts. Send for your up-to-date copy, today.

The CHAPMAN VALVE Mfg. CO.

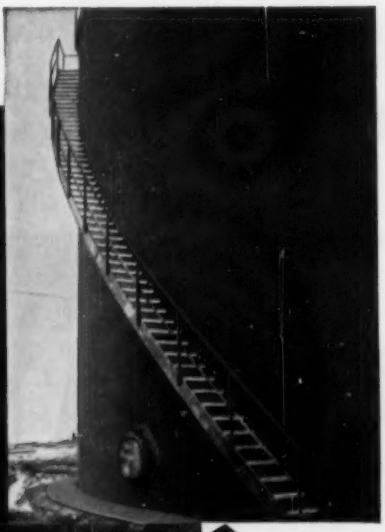
INDIAN ORCHARD, MASS.

For more data on advertised products, use Readers' Service Cards, last page.



Use SAFETY GRIP-STRUT grating

Wherever a safe footing is required



Grip-Strut circular stairway on Shell Oil tank in Portland, Ore.

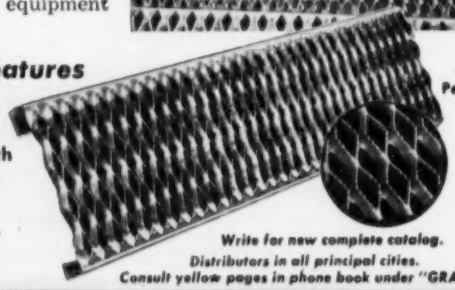
See how Shell Oil uses Grip-Strut for a safe ramp between tanks.

View looking down circular stairway on Shell Oil tank shown above.

SAFETY GRIP-STRUT is the new basic material, all in one piece (including channels), not welded, riveted or expanded in steel or aluminum, in standard sizes and gauges. Safety GRIP-STRUT presents an open space, in a diamond pattern, in excess of 55% of the area for ready access of light and air and gives a positive NON-SKID footing in all directions. Ideal for work platforms, stair and ladder steps, flooring, balconies, catwalks, machinery guards, fire escapes and for original equipment safety treads.

Important Safety Features

- ★ Fire proof
- ★ Slip proof
- ★ Maximum strength
- ★ Minimum weight
- ★ Easy to stand on
- ★ Cool in summer—warm in winter



Pat. Pending

Write for new complete catalog.

Distributors in all principal cities.

Consult yellow pages in phone book under "GRATING"

GRIP-STRUT division

THE GLOBE COMPANY • *Manufacturers since 1914*

4008 S. PRINCETON AVE. • CHICAGO 9, ILL.

Suppliers . . .

previously was general manager of the Southwest division headquartered in Temple, Texas. Before that, he was with Union Asbestos Insulation division for 12 years as sales manager of the Industrial Insulation division.

The Babcock & Wilcox Company has elected **L. S. Wilcoxson** to its board of directors. He is a vice president of the company. In addition to his duties as a director, Wilcoxson will continue in charge of the Boiler division.

Wentworth

Fraser

Worthington Corporation has appointed two commercial vice presidents. They are **A. William Fraser** and **Clarence S. Wentworth.**

Fraser, who has been Midwest regional sales manager since 1951, is in charge of district sales offices at Chicago, Denver, Kansas City, St. Louis and Minneapolis. He headquarters in Chicago.

Wentworth is sales manager of the Central region, with headquarters in Cleveland. He has responsibility for district sales offices at Buffalo, Cincinnati, Cleveland, Detroit and Pittsburgh.

With the company since 1929, Fraser served successively as sales engineer, Chicago district manager and general European manager before his appointment to the Midwest region.

Wentworth, who has been with the company since 1922, served as service engineer in Los Angeles, general line salesman at St. Louis and Chicago, Southwestern representative for the Railroad division and district manager at Detroit. He was appointed Central regional sales manager in 1955.

Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation, has made a number of changes in its Industrial Chemicals sales organization.

M. W. Duncan has been appointed manager of the Kansas City district.

T. F. Grady has been transferred to the Denver sales office as technical representative.

R. E. Gustafson has been appointed technical representative in the Chicago district.

M. H. Mackay has been transferred to the Chicago district office as an inside salesman.

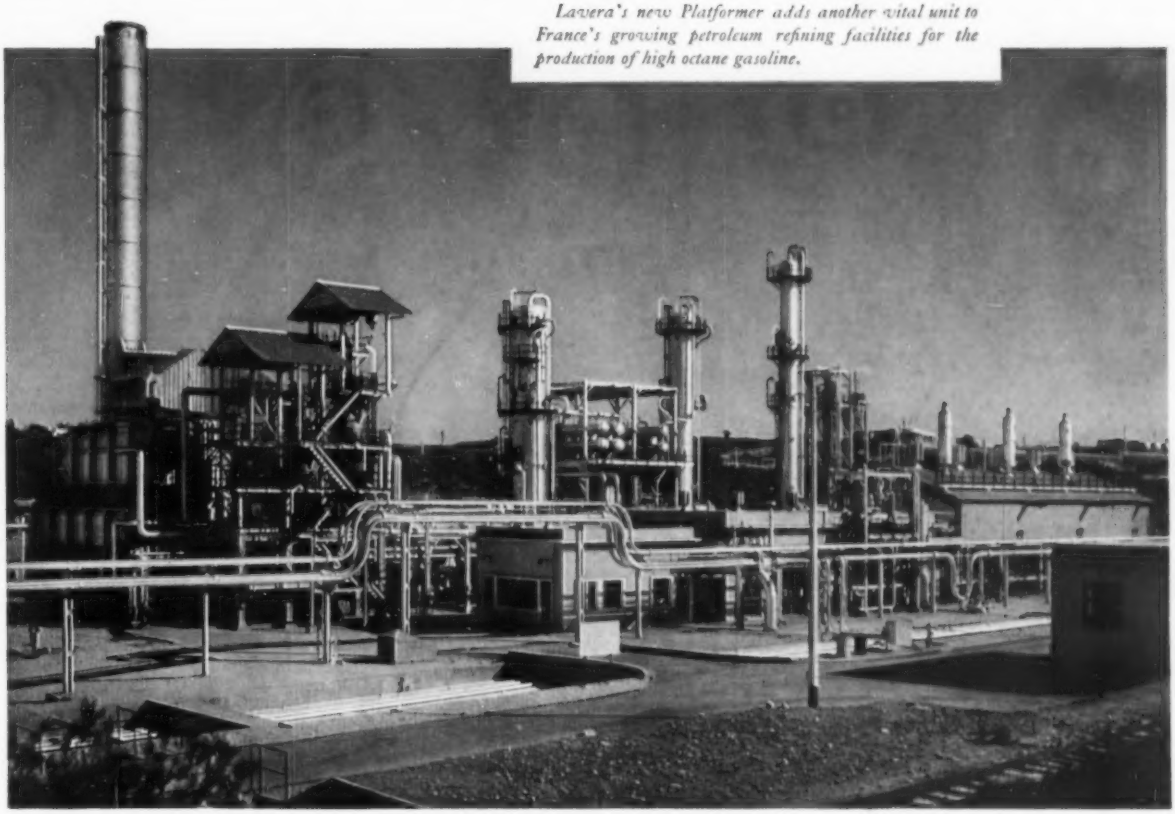
The Perkin-Elmer Corporation has named **Van Zandt Williams** as general manager of a newly-formed Instrument division. The new unit will be responsible for development, production and sale of analytical instruments.

Dr. Williams has been with Perkin-

For more data on advertised products, use Readers' Service Cards, last page.

The Latest at LAVERA...

Lavera's new Platformer adds another vital unit to France's growing petroleum refining facilities for the production of high octane gasoline.



At the Lavera Refinery of Société Française des Pétroles BP, near Marseilles, France, a 6000 BPSD catalytic reforming unit has recently been completed.

In the design and construction of this modern processing unit the engineering knowledge and methods of three great nationalities were coordinated and combined for the progress and expansion of free world enterprise. The unit embodies the latest United States design techniques, adapted to French standards by English and French engineers. It incorporates materials and equipment largely of French manufacture and was constructed by French mechanics.

Stone & Webster Engineering Corporation, in cooperation with its British and French affiliates, provided the necessary engineering, procurement and supervisory construction services.

This and the similar units erected at Kent Oil Refinery Ltd. and National Oil Refineries Ltd. for The British Petroleum Company Ltd., in the United Kingdom illustrate the international scope of integrated assistance available to refiners throughout the free countries of the world by the Engineering Corporation and its affiliates.

Write or call us for information as to how our experience may be of assistance to you.

STONE & WEBSTER ENGINEERING CORPORATION

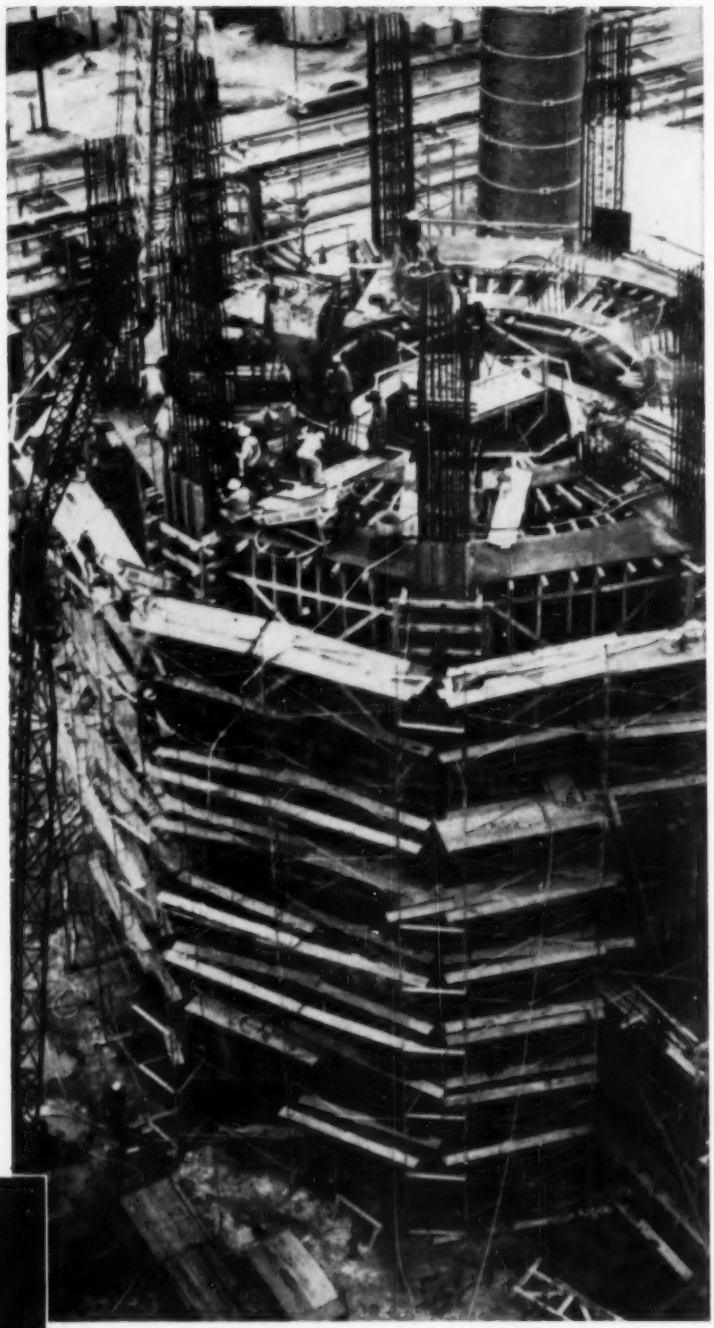
BADGER PROCESS DIVISION

AFFILIATED WITH E. B. BADGER & SONS LIMITED (LONDON)

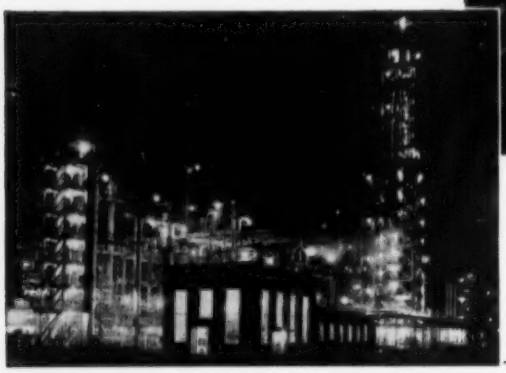
New York Boston Chicago Pittsburgh Houston San Francisco Los Angeles Seattle Toronto

Going UP!

World's Largest Airlift TCC Unit is now being built at Beaumont, Texas. This 35,000-Barrels-A-Day Unit is one of 50 Airlift TCCs built or building all over the world.



Part of New York's skyline—TCC Unit at Socony Mobil's Brooklyn refinery.



West Germany—TCC Unit at Heide Refinery of Deutsche Erdol-A.G.

TCCs are operating on all six continents—from Finland to Formosa, from Australia to Turkey

The Airlift Thermofor Catalytic Cracker is licensed by:

SOCONY MOBIL OIL COMPANY, INC.

26 Broadway, New York 4, N. Y.

Suppliers . . .

Elmer since 1948, when he started as director of instrument development. In 1951 he was elected vice president and director.

Prior to his new appointment, Dr. Williams was responsible for the company's sales and research program.

General Electric Company is planning a $1.2-million expansion and modernization program for its Small Turbine and Supercharger department. Plans call for the erection of a new high-pressure boiler plant.

The plant, which will produce steam for the testing of the department's product, will contain a 60,000-pound an hour boiler and superheater with an initial steam output of 1800 psig at 1050 F. It will be built at Fitchburg, Mass.

Koppers Company, Inc., has promoted **James M. Veeder** to vice president and manager of its Finance department. He had been assistant manager of the department since 1946.

E. A. Berry, who was vice president and manager of the Finance department, has been appointed assistant to the president. And **Charles G. Strang,** former assistant vice president in the department, has been made vice president and assistant manager.

General Electric Company has made **Kenneth E. Glover** a specialist in operations research and synthesis for its Distributions Assembly department. He will headquarter at the company's Plainview, Conn., plant.

Glover joined GE in 1950 as a design engineer. Two years later, he was appointed manager of the department's plant at Houston. In 1953, he became manager at the plant in North Hollywood, Calif.

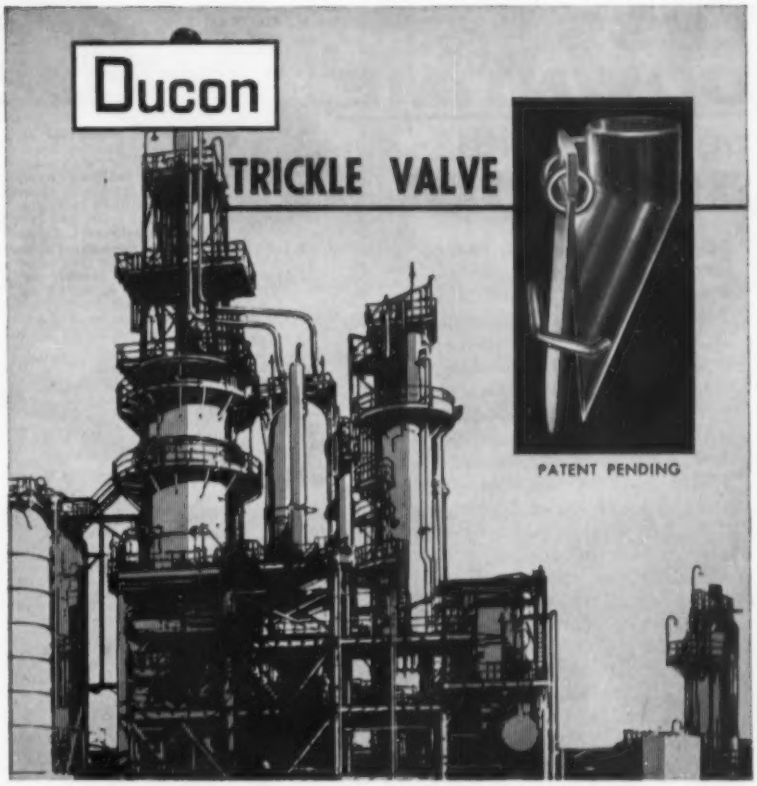
Automatic Power, Inc., is a new concern organized to manufacture packaged power units. The firm, headquartered in Houston, is headed by **N. H. Jones,** president. Other officers are **R. C. Lockwood,** vice president, and **John Ryan,** secretary and treasurer.

Borg-Warner Corporation has acquired York Corporation, which will be operated as a separate division of Borg-Warner. Present policies, management and personnel of York will continue.

Tracerlab, Inc., has elected **William E. Barbour, Jr.,** as chairman of the board, and named **William O. Faxon** to succeed him as president. Barbour had been president of the company since it was organized. Faxon was executive vice president.

Laclede-Christy Division, H. K. Porter Company has increased its sales staff, naming **William E. Whitehouse,** formerly with Kaiser Steel Corporation, as its representative in Denver. Whitehouse joined Laclede-Christy after six years refractory-maintenance experience in Kaiser's Brick Mason department.

The Timken Roller Bearing Company is losing its general production manager, James F. Reid, to the Commerce Department. Reid, who is retiring after 37 years with the company, will become assistant director and chief of the Ferro Alloys section of the Iron and Steel



. . . the first dip-leg SEAL with approval for fluid catalytic cracking plants

Ducon's trickle valve has been *approved* throughout the refining industry, as a "fool-proof" dip-leg seal. Here is the result of years of specialized experience . . . the kind that pioneers progress . . . the kind that has earned for Ducon recognition as a leader in the field of catalyst and fluid solids recovery.

Over 500 trickle valves already in service are proving the effectiveness of the following features:

COMPLETELY AUTOMATIC DIP-LEG SEAL
MINIMUM CATALYST LOSS AT START-UP
ASSURANCE OF DIP-LEG SEAL DURING UPSET
ELIMINATES ALL ADDITIONAL AERATION
MAINTENANCE-FREE CONTINUOUS OPERATION

Write for Bulletin

the name in dust control

THE Ducon COMPANY

Canadian Branch: THE DUCON COMPANY of CANADA, Ltd.
275 James Street North, HAMILTON, ONTARIO

147 EAST SECOND STREET, MINEOLA, N.Y. • Sales Representatives in Principal Cities

Designers and Manufacturers of Dust Control Equipment Exclusively

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

For more data on advertised products, use Readers' Service Cards, last page.

LESS DOWNTIME per year with AIRETOOL

An AIRETOOL tube maintenance program including regular use of AIRETOOL Tube Cleaners, Expanders and the Tube Expansion Control System, will keep your operation at peak efficiency and top production while reducing tube failure downtime to a minimum.

The hardest deposits are quickly removed from straight or curved tubes, quickly and thoroughly, with AIRETOOL'S powerful hi-speed cleaners that won't bog down. You roll tight, accurate tube joints with maximum bond when AIRETOOL Tube Expanders are used, while the unique AIRETOOL Tube Expansion Control System can cut time in half, when you overhaul or retube a bundle.

AIRETOOL 6000 SERIES CLEANER

Airetool ball bearing motor with single expansion cutter head. Motor is slip-fit constructed, has front and rear ball bearing thrusts. Cutter heads are precision made from special heat treated alloy steel, will quickly and thoroughly remove all foreign deposit from tubes. P-Type cleaner head shown is only one of many types available.

COLLINS 3-ROLL EXPANDER

Airetool Tube Expanders are made from finest alloy steel, expertly designed, precisely machined and heat treated for enduring service. Parallel rolling, self-feeding, they produce uniform expansion and tightness throughout the full thickness of the tube sheet. The G-100 5-roll expander is just one of many available for refinery use.

AIRETOOL TUBE EXPANSION CONTROL SYSTEM

The Airetool Tube Expansion Control System *automatically* and accurately rolls tube joints at production line speeds. Eliminates the danger of over or under expansion, fracture or distortion of tube sheet ligaments. Completely portable for field, shop or new work.

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge.
REPRESENTATIVES in all principal cities of U.S.A., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii.
EUROPEAN PLANT: Vlaardingen, The Netherlands

There's an AIRETOOL Tube Cleaner and Tube Expander for every type of Tubular Construction.

Suppliers . . .

division of the Business and Service Administration.

Reid joined Timken in 1919 as a clerk. He was promoted first to production manager of the Steel and Tube division, then to assistant general superintendent and finally to general production manager in 1945. He was loaned to the War Production Board from 1942 to 1945.

Solvay Process Division, Allied Chemical & Dye Corporation, has made five new appointments in its sales staff.

Hugh W. Causey, manager of Solvay's Charlotte, N. C., sales branch since 1951, was named assistant director of sales. **Robert P. Baynard** succeeds him as branch manager.

Robert L. Reynolds has become manager of the newly-created Organic Chemicals section; **George R. Barclay** was named assistant to the manager of the Special Alkalies section, and **Ronald Lovatt** has assumed the position of supervisor of the Calcium Chloride section.

The Kendall Company will erect a new $1-million plant for the manufacture of plastic film and adhesive tape coatings at Franklin, Ky. The initial unit will provide 35,000 square feet of floor space, more than triple the production of polyethylene protective tapes.

Sellers Injector Corporation has acquired the line of injectors formerly manufactured by Ohio Injector Company. In addition to manufacturing rights, the transaction includes spare parts, servicing and reconditioning facilities, all of which are now at the Sellers plant in Philadelphia.

Efforts of Ohio Injector will be devoted to the manufacture of industrial valves.

American Mannex Corporation has opened a new and enlarged Southwestern headquarters in Houston. The new office will be under the direction of **Hans Kayem, manager.**

Together with a sub-office, which the company will continue to maintain in Dallas, the new office will represent an important expansion of the company in the Southwestern area.

Dresser Industries, Inc., has opened a new Washington, D. C., office, established a new Government department and named a retired Army officer, Brig. Gen. Urban Niblo, as director of government operations with headquarters in Washington's Folger Building.

Elliott Company has **S. W. Crisman** as its new district manager at Pittsburgh. He succeeds **J. H. Strickler,** who died March 30.

Crisman has been with Elliott Company since 1935 and was assigned as a field engineer in the Pittsburgh district office in 1937. He became assistant district manager in 1953.

General Electric Company has created four operating sections in its Medium Induction Motor department at Schenectady, N. Y., with a view to closer working relations between management and the department's manufacturing units.

Managers of the new sections are **Glenn**

For more data on advertised products, use Readers' Service Cards, last page.

How to run a gasoline plant without WATER

The new Adena plant near Fort Morgan, Colorado, was designed for unusual climatic and operating conditions. It is producing gasoline economically without using water for processing.

Flexibility is a key feature of this new plant which is operated for a combination of companies by the Pure Oil Company. Initially it is handling 10,000,000 cubic feet of gas per day. Ultimately it may go as high as 20,000,000 cubic feet per day. The plant utilizes two stages of refrigeration coupled with four stages of gas compression to meet maximum summer temperatures. During the winter it is possible to divert compressor capacity from refrigeration to additional gas processing.

The Adena plant is designed for winter conditions similar to those experienced at other cold country plants designed and built by Stearns-Roger.

Whatever the design problem, Stearns-Roger is fully prepared—a "one-stop" service for design, engineering, manufacture, construction, testing. TAKE IT UP WITH STEARNS-ROGER.

Stearns-Roger

THE STEARNS-ROGER MFG. CO. DENVER, COLORADO

DENVER • HOUSTON • EL PASO • SALT LAKE CITY, STEARNS-ROGER ENGINEERING COMPANY, LTD., *Calgary, Alberta*

For more data on advertised products, use Readers' Service Cards, last page.

How to eat your Cake and have it, too

It's a neat trick if you can do it. And you can when it comes to process pumping. Dean Brothers has a line of heavy duty centrifugal pumps—

—with a range of application that covers fully 90% of all process pumping applications,

—with mechanical reliability usually found only in costly, individually-engineered pumps,

—with a whole raft of standard features considered special on many other pumps,

—at the lowest overall cost for operation, maintenance and replacement.

Here's the "trick": all eleven pumps in Dean Brothers Series C-10 have a single cradle assembly. Only the Casing, Impeller and Suction Nozzle vary with each individual pump's capacity. Everything else is the same throughout the entire series. Such interchangeability made it possible to design and build a cradle assembly that can stand up and take the beating a process pump gets in continuous heavy duty process service—*and still be a good buy.*

If you'd like to eat your cake and have it too, get all the facts about the pumps* that cost you the least in the long run. Send for Circular No. 184A.

**Series 10, Series 20 and Series 30—to 7,000 gallons per minute capacity.*

HOW DEAN BROTHERS ENGINEERS FOR LONG PUMP LIFE

Shaft deflection causes wear on the packing or mechanical seal. So Dean Brothers makes the shaft extra big with properly proportioned overhang to minimize this deflection. Result: Fewer costly, time-consuming replacements of these vital parts.

The bigger the bearings, the longer they last. So the bearings were selected to withstand the maximum possible imposed radial and thrust loads. Result: Bearing life exceeds the time between normal plant maintenance shutdowns.

Everything is like this in these pumps. Their design incorporates recognized engineering codes. Whatever these codes recommend, Dean Brothers standard centrifugal pumps have.

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS 7, INDIANA

Centrifugal and Reciprocating Pumps • Since 1869

Suppliers . . .

A. Cook, low integral horsepower and wire mill products; **Peter N. Guernsey,** manufacturing, and **David H. Ware,** engineering of high-integral horsepower products; **George B. Woods,** AG specialty and atomic motor products, and **James H. Tyler,** medium integral horsepower products.

The Mercoid Corporation has made three new executive appointments. **Willis E. Jones** was made sales manager, with executive supervision of the general selling activities throughout the corporation.

Paul J. Provost was named manager of the Industrial Controls division. This is a newly-defined activities, closely related to the work Provost has been doing several years.

And **G. R. Folds, Jr.,** was recalled to Chicago from the West Coast. He will be assigned to work with Provost in the new Industrial Controls division.

Chicago Bridge & Iron Company has elected **Horace B. Horton** as chairman of the board. With the company since 1907, he had been president since 1945.

Ernest E. Michaels, who was executive vice president, was promoted to succeed Horton as president. **Charles S. Pillsbury,** former vice president and treasurer, became vice president and secretary, and Arthur B. Horton, former assistant treasurer, was made vice president and treasurer.

George E. Borst, district sales manager for Chicago Bridge & Iron in New York, was elected vice president.

Alloy Tube Division, The Carpenter Steel Company has assigned five sales representatives to new territories.

Arvin W. Harrington has become Eastern regional manager, succeeding **Paul E. Kelly** who was recently appointed assistant manager of sales. Harrington represented the company for the past three years in Metropolitan New York and Connecticut.

Harry A. Hauser has become Mideastern regional manager. He has been a Pacific northwest sales representative of the company since June 1953.

Harry L. Harner, formerly with Studerus Oil Company, now succeeds Hauser on the West Coast. He will live in San Francisco.

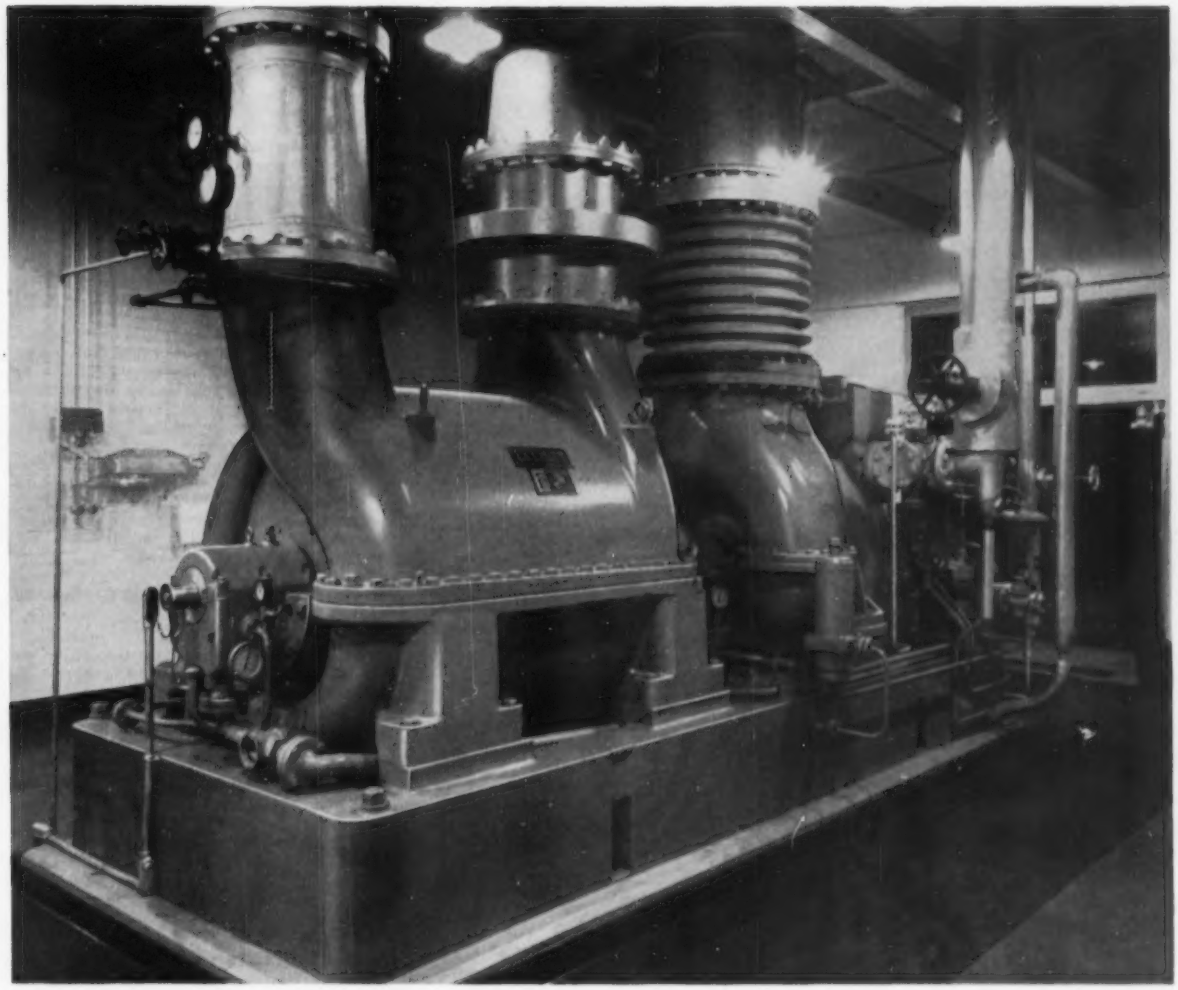
Nields B. Haas, formerly Mideastern manager, has transferred to the division's Southeastern territory composed of Georgia, Alabama and Florida. Haas has been with the Tube division nine years, having served also as territorial representative in Ohio, Pennsylvania, New York and Virginia.

Walter Joyce, formerly with Talon, Inc., succeeds Harrington in the New York and Connecticut areas.

Brown Fintube Company has selected Instrument Laboratory, Inc., as its sales representative in the Pacific Northwest. Instrument Laboratory has offices in Seattle and Portland.

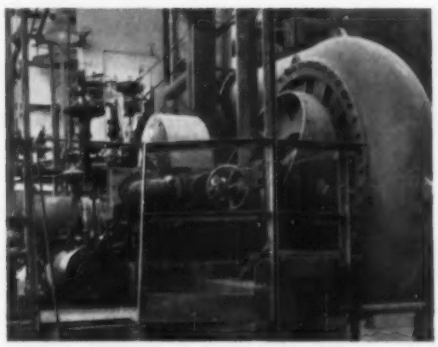
Lukens Steel Company has made six personnel advances in its Market and Commercial Development and Sales departments.

William Butler, III, former manager of advertising and sales promotion, and **John**



Tops for Refinery Service...

ELLIOTT TURBINE-DRIVEN CENTRIFUGAL COMPRESSORS



Another cat cracker gets the benefit of an Elliott turbine-driven centrifugal compressor. Single-stage compressor handles 36,050 inlet cfm at a discharge pressure of 4.0 psig; turbine develops 890 hp at 3600 rpm.

Years of non-stop service lie ahead of Elliott turbine-driven centrifugal compressors like the one shown above which was recently installed in a new cat cracker in the Southwest. The Elliott multistage compressor, handling 19,500 inlet cfm at 22.0 psig discharge pressure, and the Elliott steam turbine, rated 2035 hp at 5800 rpm, have been teamed together by Elliott engineers. Coordinated design, and construction, followed by a combined shop test, have made this a smoothly-operating unit that performs as well as it looks.

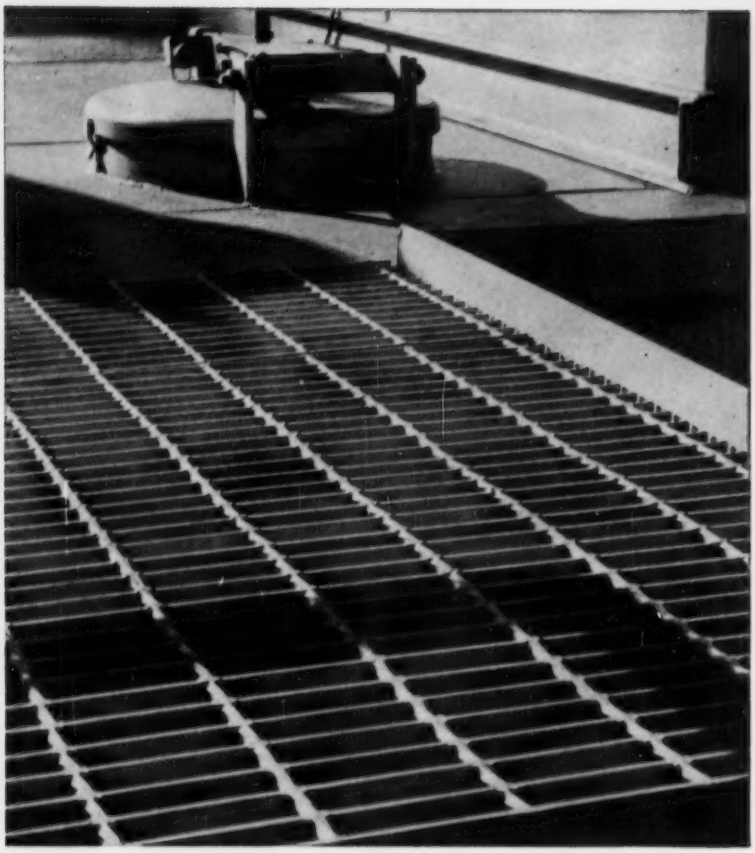
Get complete details about Elliott turbine-driven or motor-driven centrifugal compressors; ask your Elliott field engineer or write Elliott Company, Jeannette, Pa.

ELLIOTT Company

P6-2

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

For more data on advertised products, use Readers' Service Cards, last page.



... make every step a safe step

BLAW-KNOX ELECTROFORGED® STEEL GRATING and STAIR TREADS

Indoors or outdoors, you can provide safe walking conditions throughout your plant on floors, stair treads, platforms, walkways and catwalks. For Blaw-Knox Electroforged Steel Grating brings you these exclusive features:

1. rigid one-piece construction—easy to install
2. non-slip twisted crossbar—for safe footing
3. three types of bearing bars
   - square bars—for smoothest walking surface
   - knurled bars (Furro-Grip)—for extra safety plus relatively smooth walking surface
   - serrated bars—for maximum safety under extremely hazardous skid conditions
4. no sharp corners to clog—self-cleaning
5. all surfaces accessible—easy to paint
6. maximum open area—for light and ventilation

Write for your copy of new Bulletin No. 2486
—or send dimensional sketch for quotation.

50th Anniversary BLAW-KNOX 1906-1956

BLAW-KNOX COMPANY

BLAW-KNOX EQUIPMENT DIVISION

Pittsburgh 38, Pennsylvania

GRATING APPLICATIONS: floors • platforms • walkways • catwalks • stair treads • fan guards • shelving • and many other uses, both outdoors and indoors, for versatile steel grating

Suppliers . . .

B. Cording, Jr., former Syracuse sales office manager, were named assistants to **John H. Faunce, Jr.**, director of market and commercial development.

Butler, at Lukens since 1934 and advertising manager since 1944, will serve on special assignment. Cording, who has been at Lukens since 1948, will have charge of the Commercial Development division. Both will be concerned with the company's activities in the area of business diversification.

Replacing Butler as manager of advertising and sales promotion, is **Hambleton Shepperd** who has served since 1954 as manager of marketing service. Moving into the managership of marketing service is **Joseph H. Proctor**, who has been an engineer in the department.

Charles H. Pyle, Lukens resident salesman at York, Pa., since 1949, moves to Syracuse to assume Cording's post. **William A. Kelly**, a New York sales office representative since 1953, will replace Pyle at York.

Archer-Daniels-Midland Company has opened a sales office at Houston. The manager is **Jack Calkins**, and **John Florence** has been assigned to the office as technical sales representative for the Houston area.

Calkins previously was with Frontier Chemical Company seven years in production and sales as chief chemist and district sales manager. Florence joined the company in 1955, following three years in the Marine Corps.

Singmaster and Breyer, Inc., has appointed **John A. Hufnagel** as its manager of sales and **Charles E. Kaddy** as manager of construction. The company is affiliated with The Fluor Corporation, Ltd.

Barrett Division, Allied Chemical & Dye Corporation, has named **Gerald J. Bayern** as marketing and economic analyst. He was assistant director of engineering with Foster D. Snell, Inc.

Aluminum Company of America has elected five new vice presidents. They are:

H. E. Bakken, general manager of the refining division; **J. P. Haight**, chief engineer; **Lawrence Litchfield, Jr.**, general manager of the mining division; **R. T. Whitzel**, general production manager, and **Edward B. Wilber**, treasurer. Each has been connected with Alcoa for more than 30 years.

Scovill Manufacturing Company has acquired a license from Continuous Metalcast Company, Inc., to practice the inventions of Alfred H. Tessmann in the casting of aluminum and aluminum alloys.

The practice, called "Vacuum Horizontal Continuous Casting," has been in commercial use for about a year by Southern Electrical Corporation at Chattanooga, Tenn., in the production of aluminum wire.

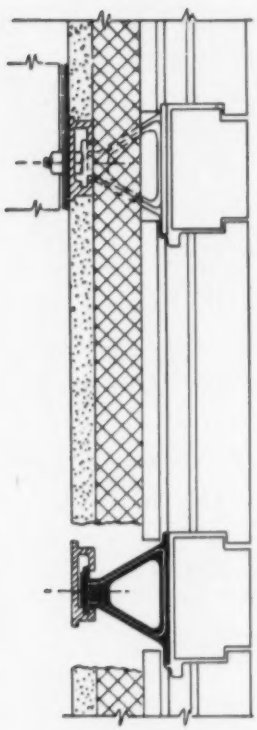
Worthington Corporation has appointed **John J. Thompson**, manager of personnel and training, as manager of a newly-created Salaried Personnel department. And **Robert C. Hughes** was made director of training, under Thompson.

Thompson will assume all functions of the corporation's present Personnel and

For more data on advertised products, use Readers' Service Cards, last page.

INTRODUCING
BIGELOW-LIPTAK'S
BI-MET*

Insulated Furnace Walls For High Temperature Applications

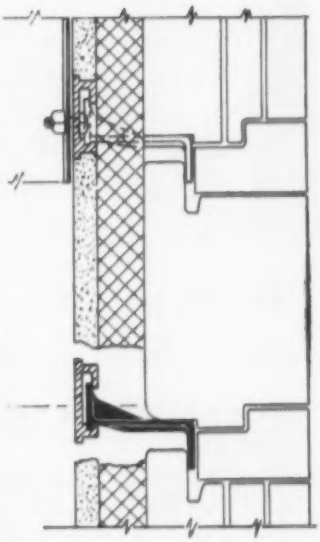


The 4½ inch wall

Here's a job-proven idea which is designed to pare the costs of suspended furnace enclosures. It's used when temperatures are going to be high and when expensive special alloy supporting castings must be used.

Two different castings are used. The first, an alloy clip casting is embedded in the tile where temperatures are highest. This, in turn, is fastened to a standard cast iron support. The design permits the most economical use of costly alloys.

This is a Bigelow-Liptak BI-MET wall and it is another example of B-L's efforts to produce quality furnace enclosures at lower and lower initial costs. Remember: a suspended enclosure for a boiler, a refinery heater, or any other type of installation, will *last longer, have less down time for repairs.* That makes a suspended job the cheapest in the long run. Want to cash in on savings like these? Contact the B-L office nearest you.



The 7 inch wall

*PATENT APPLIED FOR

BIGELOW-LIPTAK *Corporation*

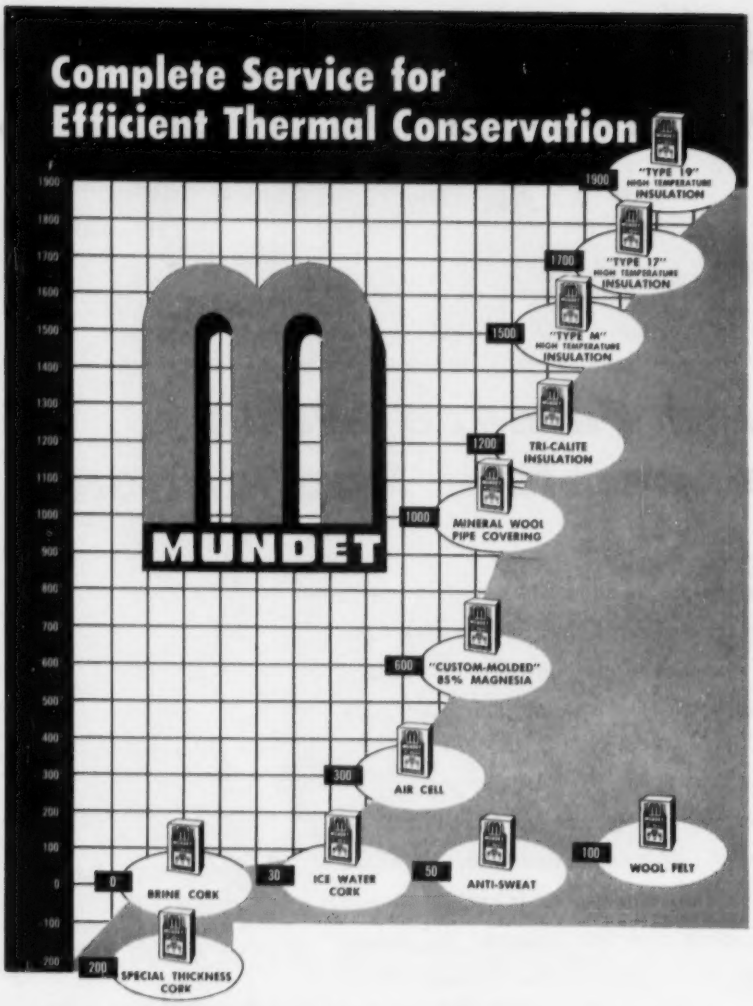
AND BIGELOW-LIPTAK EXPORT CORPORATION
2550 WEST GRAND BOULEVARD, DETROIT 8, MICHIGAN

UNIT-SUSPENDED WALLS AND ARCHES

In Canada: BIGELOW-LIPTAK OF CANADA, LTD., *Toronto, Ontario*

ATLANTA • BOSTON • BUFFALO • CHICAGO • CLEVELAND • DENVER • HOUSTON • KANSAS CITY, MO. • LOS ANGELES • MIAMI • MINNEAPOLIS • NEW YORK • PHILADELPHIA • PITTSBURGH • PORTLAND, ORE. • ST. LOUIS • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SEATTLE • TULSA • MONTREAL • SAULT STE. MARIE, ONT. • VANCOUVER • WINNIPEG

For more data on advertised products, use Readers' Service Cards, last page.



Prompt Insulation Services are Provided by Mundet for Refinery Applications . . .

Mundet industrial insulations in pipe covering and blocks are made for all temperature ranges up to 1900°F.

Our district offices, staffed with competent engineering personnel, with convenient warehousing facilities, are located in the principal refinery areas to insure prompt service in meeting individual requirements.

We suggest that you call on us for most economical solutions to thermal conservation problems. Recommendations and estimates are furnished without obligation. Write for new bulletin describing Mundet High Temperature Insulations.

MUNDET CORK CORPORATION

INSULATION DIVISION • 7101 Tonnelle Ave., North Bergen, N. J.

ATLANTA 339-41 Elizabeth St. N.E.	**HOUSTON 11** 6601 Supply Row	**LOS ANGELES** (Maywood): 6116 Walker Ave.	**PHILADELPHIA 39** 856 N. 48th St.
CINCINNATI 2 427 West 4th St.	**JACKSONVILLE 2, FLA.** 520 E. Bay St.	**NEW ORLEANS 16** 315-25 N. Front St.	**SAN ANTONIO** 130 Lombrano St.
DALLAS 10 601 Second Ave.			**SAN FRANCISCO 7** 440 Brannan St.
DETROIT 38 14401 Prairie Ave.	**KANSAS CITY 1, MO.** 1210 W. 9th St.	**NEW YORK 17** 331 Madison Ave.	**ST. LOUIS 9** 3176 Brannon Ave.

In Canada: Mundet Cork & Insulation, Ltd., 35 Booth Ave., Toronto

Suppliers . . .

Training department and will have full responsibility for the development and coordination of a management-development program which will include all training activities throughout the corporation.

His experience with Worthington includes application engineering work in district office and product division operations. He served as sales Engineer in several district offices; as assistant district manager of the corporation's Cincinnati office, and since 1951 as manager of the Personnel and Training department at Harrison, N. J.

Hughes will be responsible for all training activities and college relations, including the company's recruiting programs.

He joined Worthington's Air Conditioning and Refrigeration division in 1953 as a distributor supervisor. In 1955 he was appointed manager of sales training for the division.

American Cyanamid Company has named **Richard O. Roblin, Jr.,** and **Robert P. Parker** as assistant general managers of its Pigments and Research divisions.

Dr. Roblin, formerly assistant general manager of the company's Research division, has been with Cyanamid since 1934 when he joined the Warners, N. J., plant as a research chemist. In 1936 he was appointed a group leader at the Stamford laboratories, becoming director of its Chemotherapy division in 1942. He was appointed assistant manager of the Research division in 1954.

Dr. Parker, who was director of research at the Pearl River laboratories, joined the Cyanamid organization in 1933. As a chemist at the Bound Brook plant, Dr. Parker did considerable work in dyes and pigments. In 1947 he was appointed director of chemical research at that plant and in 1952 became director of research. He was appointed director of research at Pearl River in August, 1954.

Universal Oil Products Company will construct two new buildings and an addition to its administration building in Des Plaines, Ill., at a cost of approximately $750,000. Occupancy is expected by January 1957.

An automotive laboratory, containing approximately 8000 square feet of space, will house knock-testing engines and special dynamometer test equipment used in research on fuels, lubricants and additives. Along with provisions for storage of corporate records, the other new building will provide space for maintenance shops and supplies.

Consisting of two floors and a basement, the new wing on the administrative building will be occupied by Procon Inc., a wholly-owned subsidiary.

A 100,000-gallon elevated water storage tank to insure continuous water service to the entire Des Plaines site, is already under construction.

Universal also has construction started on a new manufacturing development facility at Shreveport, La., which will be used for work in connection with manufacturing problems. A one-story steel and transite structure, it is expected to be in use by mid-July.

The Babcock & Wilcox Company has entered an agreement with Brown Company, a New England paper manu-

For more data on advertised products, use Readers' Service Cards, last page.

ÆSOP'S FABLES No. 2

The hungry Wolf saw Mrs. Goat feeding at the top of a steep precipice, where he had no chance of reaching her. Again and again he implored her to come down where the grass was much sweeter and more abundant. Finally, she replied: "Are you certain, friend Wolf, that it is *my* supper you are so concerned with, and not your own?"

Moral:

The friend with an ulterior motive can be dangerous.

. . . we *confess* an "ulterior motive" but, a beneficial one . . . the more good companies such as yours that become aware of the "outage time" and money *saved* with superior ADAMANT Fire Brick Cement . . . or any of the popular ADAPRODUCTS Line of Refractories . . . the greater opportunity we have to be of service and fill your *every* Refractory requirement.

Our new Bonding Mortars bulletin #3 will gladly be sent upon request.

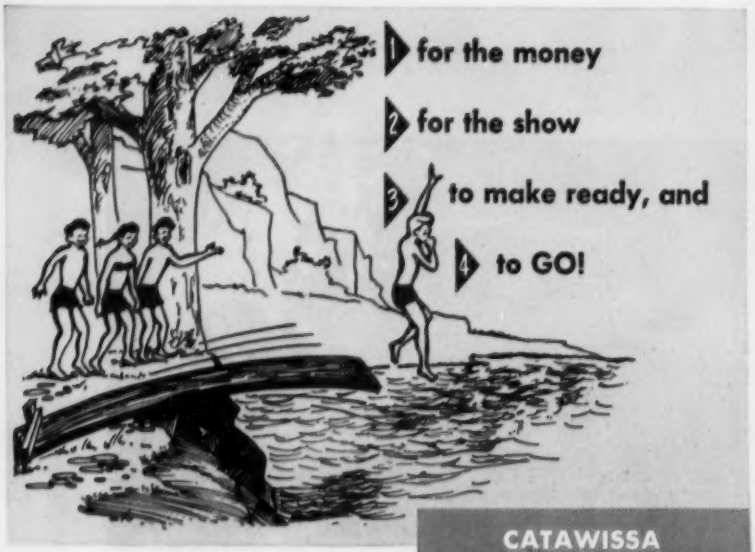
Botfield

ESTABLISHED 1907

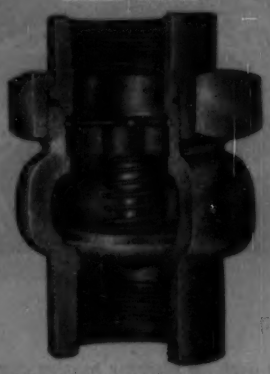
REFRACTORIES

ADAMANT and other ADA products

swanson and clymer sts.
philadelphia 47, penna.



CATAWISSA
400-M
SPRING CONTROLLED
CHECK VALVE



THE CHECK VALVE WITH THE
PERFECT SEAL
UNION CONNECTION

1 Compare the price tag
of a Catawissa 400-M Spring Controlled Check Valve against any check valve of its kind on the market!

2 Consider the appearance
of Catawissa 400-M Check Valves. Precision machining of contour steel castings and forgings makes the big difference!

3 Ease and speed of application
make Catawissa 400-M Check Valves ideal for jobs where valuable space is wasted on the full union and nipple necessary to install the conventional type check valve!

4 Observe the heavy wall sections
of the nickel semi-steel body and forged steel coupling nut, where strength counts!

Gives Positive Seating, Eliminates Vibration or Hammering
in vertical or horizontal use

☆

All Applications
including mild, common acids; non-oxidizing alkalies; hydro-carbons and ammonia.

☆

Sizes 1" thru 3"

You can forget your check valve problems when you install Catawissa 400-M Spring Controlled Check Valves! They're built to last indefinitely with Catawissa's exclusive 3-to-1 Safety Factor, the extra value feature of all Catawissa products . . . your assurance of trouble-free service.

These valves are more easily accessible than any other type spring controlled check valve on the market. The single union connection may be broken and working parts removed for repairs or inspection without removing the valve from the line.

• AT YOUR FAVORITE SUPPLY STORE •
CATAWISSA VALVE AND FITTINGS COMPANY
CATAWISSA, PENNA.

Suppliers . . .

facturer, whereby B&W will license Brown to install its magnesium-bisulfite pulping and chemical-recovery process at Brown's Nerlin, N. H., plant.

This will be the first installation in the eastern U. S. to recover both the chemical and heat values in waste sulfite liquor. Brown's installation will be completed in 1957.

Johns Manville has named Thorpe Insulation Company as insulation-contract unit for its Industrial Insulations division on the Gulf Coast. In its new capacity, Thorpe Insulation, which maintains offices in Houston, will handle contract installations for Johns Manville in this area.

President and general manager of Thorpe Insulation is **W. R. Downs.**

The new contract unit will be supported by engineering and sales forces in the Johns Manville regional office at Houston. This office is under the direction of **C. B. Hann,** regional manager, and **R. A. Stapleton,** area sales manager.

The Cooper-Bessemer Corporation has assigned **Richard L. Spetka** to its New York Domestic office. He will assist in engineering and sales, under the direction of **Charles M. Reagle,** vice president and district manager, and **George W. Edick,** branch manager.

Spetka is a registered professional engineer. He previously spent three years with the U. S. Army Engineers.

Union Asbestos & Rubber Company has named a vice president, **William H. Fehrs,** as manager of sales for its Hand Brake division. Fehrs, who also is secretary of the company, has been assistant director of sales.

He joined the company in 1928. Two years later, he was made assistant to the vice president of the Automotive division, subsequently becoming the division's sales manager.

Later, he was manager of the Cicero factory, and in 1944 was made assistant to the president in charge of railroad sales, a position he had held four years when he was elected vice president. He has been secretary since 1955.

Worthington Corporation has appointed **Douglas L. Heisler** as purchasing manager for its Harrison division. He had been general purchasing assistant for the corporation since 1952.

The Cooper-Bessemer Corporation has elected **E. L. Miller** as assistant general manager.

Miller's new position places him directly under the president and general manager of the company. In this capacity, he has responsibility for the company's overall operations.

Miller joined the Engineering department of Cooper-Bessemer in 1946, and was appointed assistant general manager in 1954.

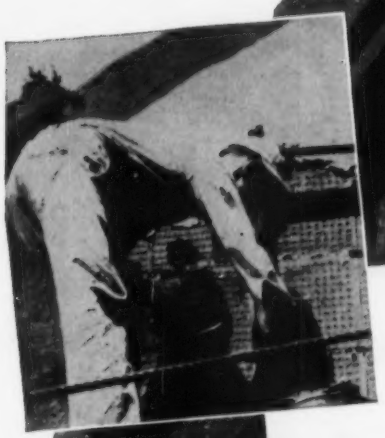
West Instrument Corporation has appointed **James A. Hartnett** as managing director of West Instrument, Ltd., a British subsidiary.

He previously was with the English subsidiary of Minneapolis-Honeywell Regulator Company. He was with this com-

"Inside-out" Furnace Construction calls for BALDWIN-HILL dual purpose

SUPER POWERHOUSE CEMENT

B-H Super Powerhouse Cement applied over B-H Mono-Block on Riley-Stoker Pressurized Furnace at large chemical plant.



it Insulates as it Finishes . . .

- Dries fast to smooth, glazed white finish; may be painted with water or oil-base paints or weatherproofed for outdoor application.
- Does not wash off after initial set if exposed to rain before application of weatherproofing.
- Dries without shrinking; no reworking to point up shrinkage cracks.
- Easily troweled; excellent adhesive qualities prevent fall-off during application.

See our catalog in Sweet's Plant Engineering File or write for a copy.

BALDWIN-HILL COMPANY

705 Breunig Ave., Trenton 2, N. J.

Huntington, Ind. Kalamazoo, Mich. Temple, Texas

BALDWIN-HILL BH INSULATIONS

COMPLETE LINE OF BALDWIN-HILL INSULATING PRODUCTS

B-H Mono-Block	B-H Super Powerhouse Cement	B-H No. 100 Pipe Insulation
B-H Blanket	B-H No. 1 Insulating Cement	B-H 85% Magnesia Pipe Insulation
B-H Koldboard	B-H No. 52 Asbestos Cement	B-H Calcium Silicate Pipe Insulation
B-H Bond-Tite	B-H Spun Felt Insulation	B-H Mono-Kover Pipe Insulation
B-H Weatherseal	B-H Fine-Fyber Felt Insulation	B-H Spun Mineral Wool Fill

For more data on advertised products, use Readers' Service Cards, last page.

FOR TESTING AIRCRAFT GAS TURBINE AND JET PROPULSION FUELS . . .

GOV'T. METHOD 3703 and ASTM D-1319 F.I.A.

(Fluorescent-Indicator Adsorption)

ULTRA - VIOLET Model X-40 . . . single tube, 3650 Angstrom units, length 49" overall, 40 watt. For 110 volts A.C.

$44.75 COMPLETE

Also Complete Range of Ultra-Violet Sources . . . 3660 A.U. and 2537 A.U. available in laboratory, industrial, and portable models.

IDEAL FOR CHROMATOGRAPHY

BLACK LIGHT CORP. OF AMERICA

Distributors for Ultra-Violet Products, Inc.

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SAN GABRIEL, CALIF.
Distributors in Principal Cities

Are your operations as efficient as they might be?

- Does your scheduling adjust easily to changes in price structure? in demand? in quality specifications? in capital available for new equipment?

SCHEDULING OF PETROLEUM REFINERY OPERATIONS

By Alan S. Manne—Mr. Manne, an economist for the RAND Corporation, demonstrates in this book the value of applying mathematical economics to typical refinery scheduling problems. He presents a number of case studies of such problems, each of them showing how an application of mathematical economics works out. The many possibilities he reveals for adjusting refinery operations to changing circumstances hold high interest for the refinery operations planner. Glossary of technical terms, tables, figures and diagrams.

$5.00 through bookstores or order from

HARVARD UNIVERSITY PRESS
Dept. B-1, 44 Francis Avenue
Cambridge 38, Massachusetts

Suppliers . . .

pany 17 years and spent several years with the oil industry in Persia.

The West affiliate operates a new plant in Brighton, Sussex.

Claud S. Gordon Company has appointed **Samuel Stanton** as its district manager in Detroit. For the past ten years, he has been a manufacturers' representative in Detroit.

Colton Chemical Company, a division of Air Reduction Company, Inc., has expanded its sales and service territory under the Chicago office to include Minneapolis, St. Paul, Kansas City, St. Louis and Wichita.

Manager of the Chicago district is **James K. Ames.** The company has named **David M. Stettler** to assist him in sales and service.

Ames joined the company as technical service representative and assistant to the vice president. In 1954 he moved to Chicago to open a district sales office. Stettler formerly was with Mine Safety Appliance Company.

Colton Chemical Company also has appointed **Charles J. Vickers** as manager of technical sales and service for its Colfoam Microballon Spheres department.

Vickers formerly was with Allied Chemical & Dye Corporation. His duties in the Colton organization will be to head up and coordinate all activities connected with selling and servicing for the division.

Worthington Corporation has appointed **Charles D. Cummins** as district manager at Seattle. He has been assistant district manager there since 1949.

In his new position, Cummins succeeds E. D. Schively who was given a special assignment in Worthington's new Canadian operation.

The Seattle district maintains a branch office at Portland, in charge of **Norman E. Wolfe,** and a sales operation in Spokane under **Harley M. Yake.**

Cummins joined Worthington in 1925 as a general line salesman at Seattle and in 1949 became assistant district manager of the office.

Schively joined the company in 1916. He served in various sales capacities until his appointment as district manager at Salt Lake City in 1920. He was made manager of the Seattle district in 1924.

A. P. Green Fire Brick Company has elected **Charles C. Morley** as treasurer. For the past three years, he has been the company's controller.

Morley has been with the company 28 years. During most of this time, he has been associated with the Finance division.

Laclede-Christy Company, division of H. K. Porter Company, Inc., has started the initial phase of a $1.5-million expansion, with the installation of new equipment at its plant in St. Louis.

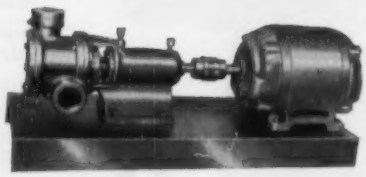
New grinding, screening and sacking facilities—due to be in operation shortly—are designed to improve product quality and increase production of the St. Louis plant.

Laclede's plant at Clearfield, Pa., will install new gas-burning equipment expected to increase brick production by 15

by PROGRESS
out of NECESSITY

The **NEW!**
APCO Z4
Process **PUMPS**

for **HANDLING LIQUEFIED PETROLEUM GASES, REFRIGERANTS** *and other* **NON VISCOUS LIQUIDS** *of* **MODERN INDUSTRY**



Modern industry offers a challenge in the form of new and difficult applications which demand improved pumping techniques. In the Type Z4 APCO Turbine-Type Pumps will be found the complete answer to many of the applications involving liquefied gases and other light, non-viscous liquids. Obtainable in special metals with notable economy.

AURORA Always PUMPS

Write for BULLETIN 111-ZA

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AURORA PUMP DIVISION
THE NEW YORK AIR BRAKE COMPANY
84 LOUCKS STREET • AURORA • ILLINOIS

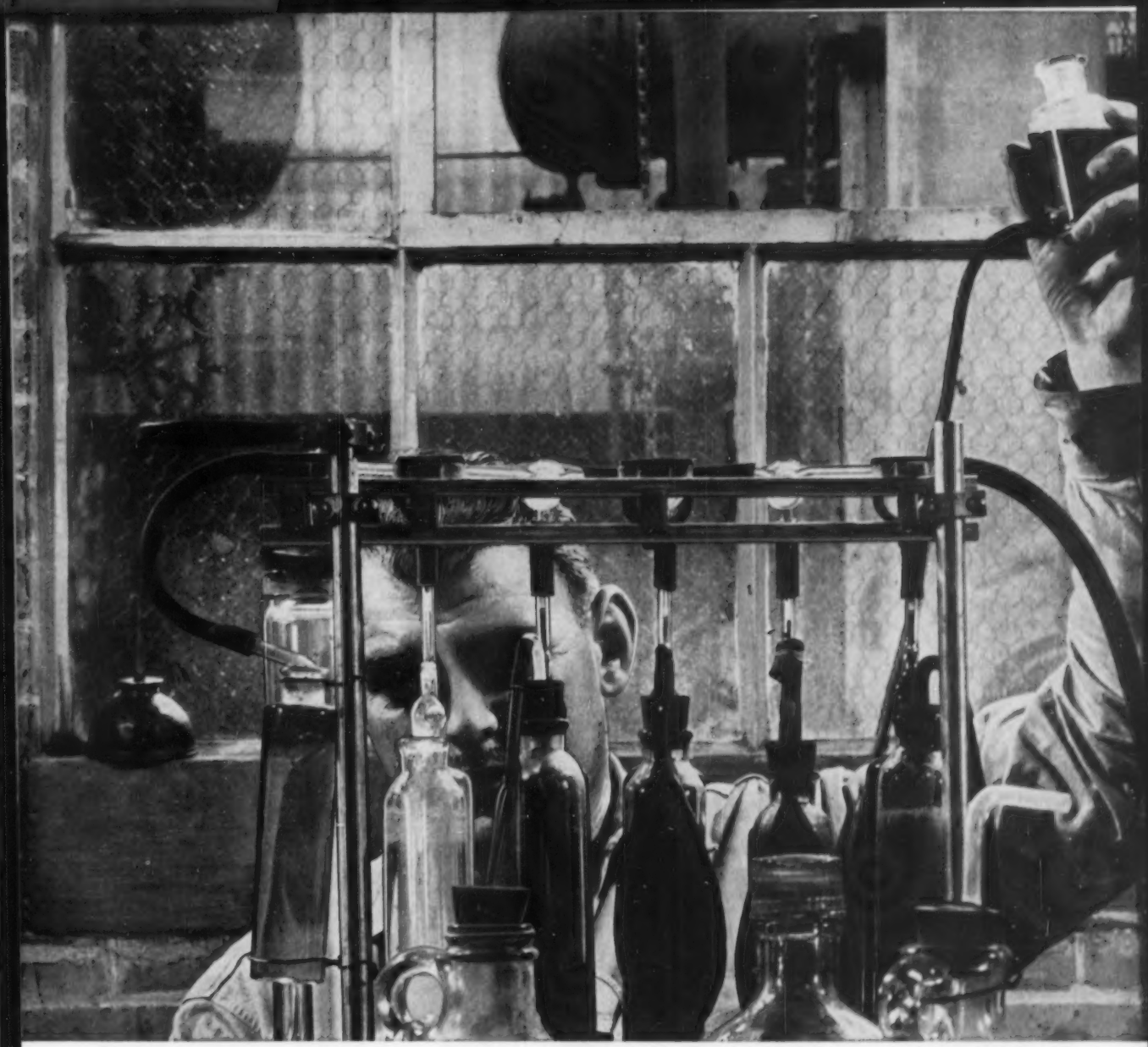


Photo courtesy Standard Oil Co., (N. J.)

boost average ratings as much as 2 octane numbers
with the LJUNGSTROM® AIR PREHEATER

With waste heat recovered and returned to the furnace in combustion air, the most modern heat-transfer systems can be operated at peak efficiency.

That's why you boost product quality with the Ljungstrom Air Preheater. Its heat-recovery efficiency makes possible advanced furnace designs that assure remarkably close control of processing. And finer control means a more uniform product . . . with average ratings as much as 2 octane numbers higher. One still's added income just from higher product quality is $58,000 annually.

How fast is "WRITE-OFF"?

In earnings from higher octane ratings, many refiners write off the cost of the Ljungstrom installation in less than two years. This time is cut to nine months and even less, when the other Ljungstrom advantages are taken into account – saves up to 20% in fuel costs . . . permits more economical furnace design, with no need for convection surfaces . . . burns many fuels you used to throw away . . . results in consistently higher through-put . . . and minimizes slag.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits obtainable in fuel burning equipment – call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljundstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

Suppliers . . .

percent. Additional storage bins will facilitate separate grinding of raw materials.

At the company's Ottawa, Ill., plant, where mechanization and modernization is already underway, more new facilities will be added. New standby oil-burning equipment is planned, and equipment for feeding, blending and storage is being added.

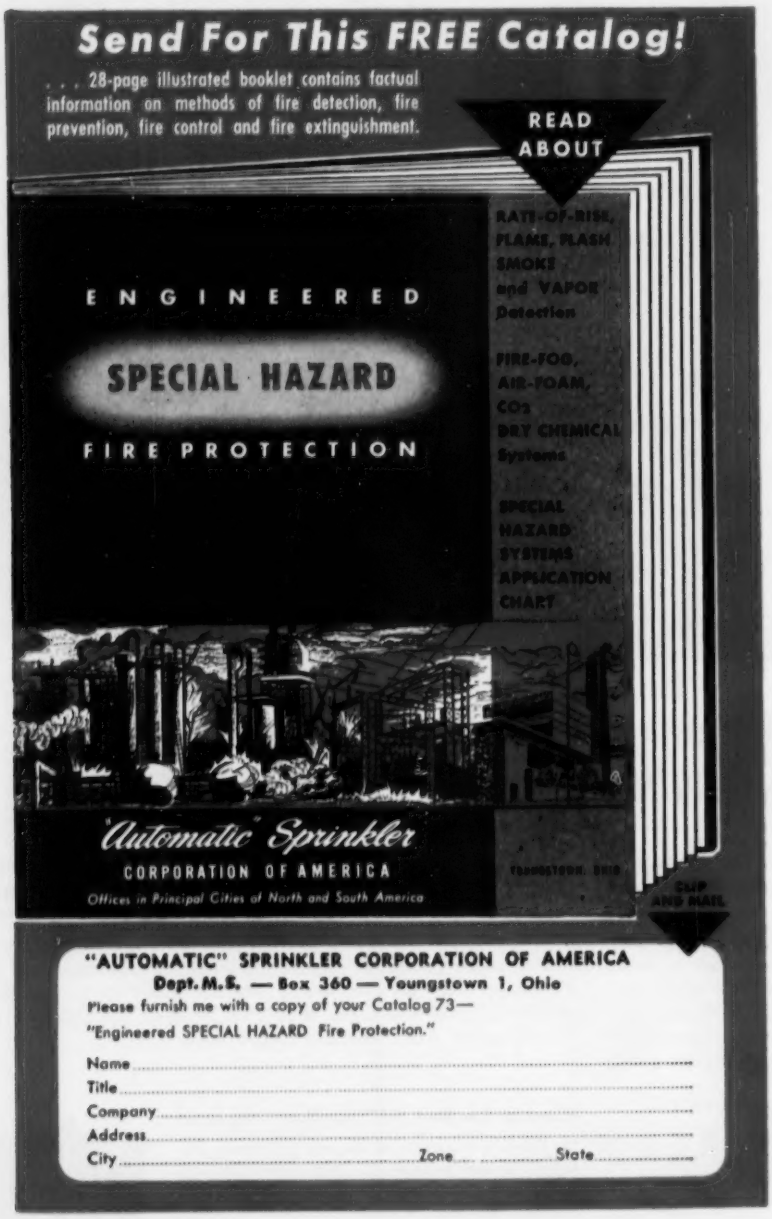
In Cannon City, Colo., Laclede's plant will supplement present manufacturing facilities to supply western markets.

And the plant at Bessemer, Ala., will install new equipment for mixing, crushing, grinding, drying and burning to improve product quality and increase production.

Lukens Steel Company has named **Joseph H. Proctor** as manager of its marketing services. He succeeds **Hambleton Shepperd** who was advanced to manager of advertising and sales promotion, replacing **William Butler, III.** Butler was moved up to become assistant to the director of market and commercial development.

Carrier Corporation will start construction this year on a $6 million plant on the West Coast for the production of air-conditioning equipment, furnaces and water heaters.

With an area of more than 500,000 square feet, the new manufacturing engineering and office facilities will be at Puente, Calif., near Los Angeles. It will provide expanded facilities for the Day & Night and Payne divisions and will produce certain types of equipment for other Carrier divisions.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Dept. M.S. — Box 360 — Youngstown 1, Ohio
Please furnish me with a copy of your Catalog 73—
"Engineered SPECIAL HAZARD Fire Protection."
Name
Title
Company
Address
City Zone State

William J. Bailey, Carrier vice-president and general manager of the divisions now located at Monrovia, Calif., will be in charge of the plant.

Burgess-Manning Company has named Bass Industrial Equipment Company as western and central New York sales representative for its Industrial Silencer division. The Buffalo concern is headed by **Roy A.,** and **Kenneth Bass.**

E. I. du Pont de Nemours & Company, Inc., has named a new regional manager, two new additives managers, a new district manager and a new account manager for its Petroleum Chemicals division.

Robert F. Harwick, formerly assistant manager of the Akron district of the Elastomers division, sales promotion manager of the Petroleum Chemicals division and Gulf Coast assistant regional manager of that division, has been named manager of the Western region. **George L. Tyler** becomes assistant manager, and **William B. Gest** has been named manager of the newly created Cleveland district.

Edison D. Jeffus, who has been manager of the Eastern Regional Laboratory, has been named to the newly created post of additives manager for the Gulf Coast region, headquartered in Houston. William W. Wingate has been appointed to the other new position of additives manager for the Mid-Continent region with the main office in Tulsa. Richard O. Braendle moves to assistant to the manager of additives sales in Wilmington, the post formerly held by Mr. Wingate.

William K. Park has been transferred from the Central region to the Eastern region as an account manager with headquarters in New York.

Carbide and Carbon Chemicals Company, division of Union Carbide and Carbon Corporation, has appointed five new district managers and two assistant district managers.

R. A. Corio has been appointed district manager for the Newark district, and **M. R. Kleeman** has been appointed assistant district manager.

B. A. Gustin, Jr. has been appointed district manager for the Boston district. He was formerly district manager at Charlotte, N. C.

R. J. Hughes has been appointed district manager at Philadelphia.

J. F. Luther has been appointed district manager for the Charlotte, N. C., district. Formerly he was district manager for the Albany district.

J. R. Retter has been appointed district manager at Albany.

William Samson has been appointed assistant district manager for the Detroit district.

The Bird-Archer Company has moved all facilities from New York to its headquarters in Philadelphia. A new laboratory, recently completed, doubles the company's capacity to test water and carry on research.

Stauffer Chemical Company has filed application with the U. S. Engineers for permission to build a major addition to its dock facilities on the Ohio River at Louisville, Ky.

The company's plans call for construction of a 700-foot dock at a cost of approximately $300,000. It will be equipped to handle unloading of 175-foot chlorine barges—which provide raw material for Stauffer's petrochemical operations at

At Warren Petroleum Taylor FULSCOPE* Controllers are HABIT FORMING!

Years of service at several Warren Plants show these qualities . . .

DEPENDABILITY

RUGGEDNESS

EASY, LOW COST MAINTENANCE

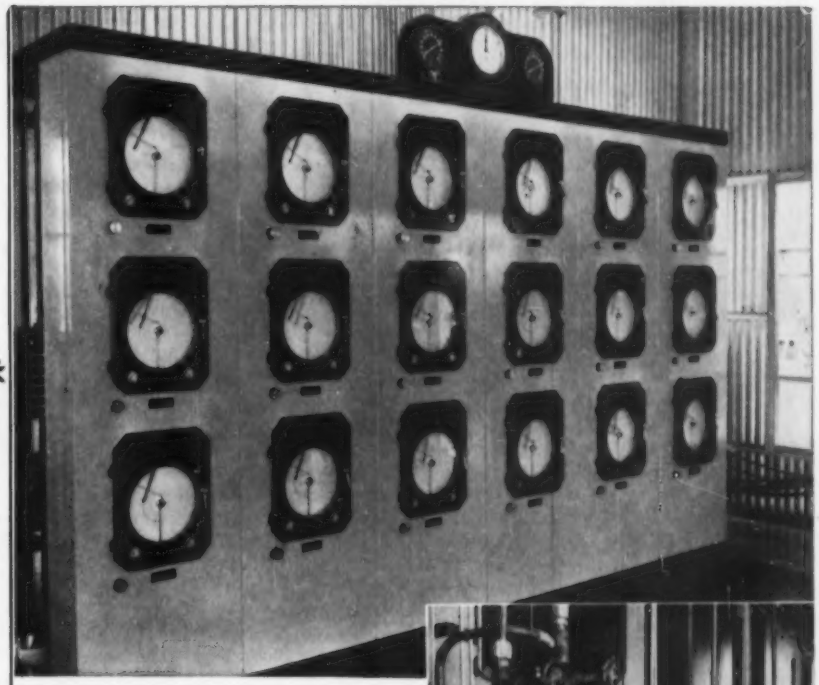
SIMPLE ADJUSTMENTS

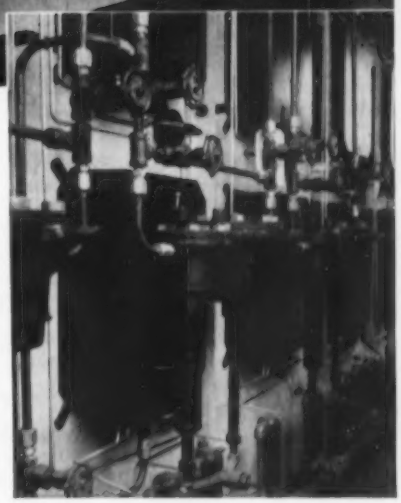
VERSATILITY

TROUBLE-FREE, SIMPLE OPERATION

LONG LIFE

*Trade Mark





Typical panel of FULSCOPE Controllers at Ringwood Natural Gasoline Plant of Warren Petroleum Corporation. (inset photo shows rear view)

SIXTEEN years ago Warren Petroleum Corporation started to equip their natural gasoline plants with FULSCOPE Controllers. Since then plants at Holliday, Monument, Wichita Falls, Antioch, Gladewater and Ringwood have been similarly equipped. The continued use of FULSCOPE Controllers in these locations is striking evidence of their reliability. Here's why they have become so popular with Warren—and throughout the petroleum industry:

1. **Extremely versatile.** Same control mechanisms are used in both recording and indicating models, as locally mounted controllers, transmitters or controlling receivers for temperature, pressure, flow or liquid level. Interchangeable unit construction permits a small inventory of parts. Pre-calibrated units eliminate expensive checking.

2. **Easy maintenance.** The skillful design makes all components readily accessible and easily adjusted or replaced.

3. **Adaptable to changing process requirements** because the FULSCOPE Controller is available in any desired combination of Proportional, Automatic Reset or PRE-ACT* (derivative) Responses.

4. **Proper adjustment is easily obtained.** Control Response Adjustment Dials are calibrated in specific units, repeatable in all instruments. Optimum settings are quickly determined.

5. **Control point always matches set point** when automatic reset is used, thanks to fully pneumatic sensitivity reduction.

6. **A trouble-free air system.** Metal disc type filters are built-in features, easily removed for cleaning. Assures exceptionally good performance under difficult operating conditions.

7. **Lifelong accuracy.** Fewer links and pivots. Sturdy but lightweight stainless steel construction nullifies wear, corrosion and vibration effects.

8. **Sturdy, purged case** with vapor-tight door.

Call your Taylor Field Engineer for more information or write for **Bulletin 98151.** Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

Taylor Instruments MEAN ACCURACY FIRST

For more data on advertised products, use Readers' Service Cards, last page.

TRIPLE ADVANTAGES EFFECTED BY *National-U.S.* EVAPORATIVE CASCADE COOLERS...

at the sulphuric acid plant of The Eagle-Picher Company Galena, Kansas

A unique installation of National-U.S. large evaporative cascade type coolers is solving the cooling problem for The Eagle-Picher Company in the manufacture of sulfuric acid at Galena, Kansas.

Each cooling unit combines the water cooling principles of a conventional wood tower with the heat exchanger principle of National-U.S. cast iron cooling sections through which the acid flows.

The advantages are three-fold:

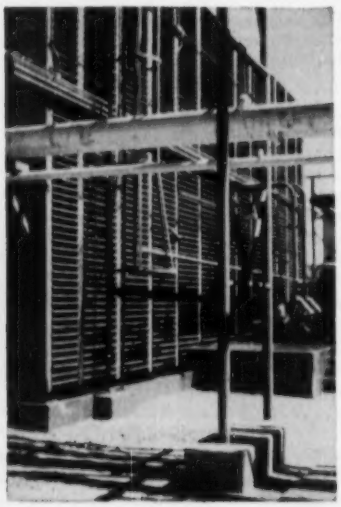
1. **SAVES WATER in an area where water is scarce—makeup quantity equal to evaporation and blowdown losses only.**
2. **SAVES SPACE—takes up little more room than a conventional raw water cooling system.**
3. **SAVES IN FIRST COST—because of reduced space and by eliminating a separate cooling tower.**

The entire cooling area is blanketed with spray from a series of jet nozzles forming a checkerboard umbrella of water over the coolers and pit. Water circulation quantity is two-and-a-half times that of a conventional installation. A proportionate cooling effect is exerted on the heated water from the heat transfer surface, plus considerable evaporative effect from warm water on the surface of the sections.

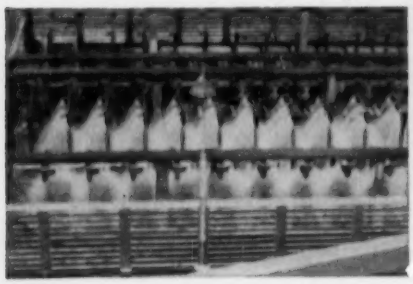
Over two years of operating experience has proved the efficiency and the triple advantages of this installation of coolers designed by National-U.S. engineers.

For full information, get in touch with National-U.S. Heat Transfer Division, whose engineers will also be glad to discuss your particular cooling problems with you.

Exterior view of the coolers at Galena, Kansas sulfuric acid plant of The Eagle-Picher Company. Note the resemblance to a conventional cooling tower. Circulating water pumps can be seen at the left.



Looking down on water sprays in operation at the evaporative cooler. (Installation was made by Leonard Construction Co., Chicago.)



HEAT TRANSFER DIVISION

National-U.S. Radiator CORPORATION

HEAT TRANSFER DIVISION HEADQUARTERS
342 Madison Avenue, New York 17, New York

Suppliers . . .

Louisville, and the loading of outgoing barges with such products as carbon tetrachloride, perchlorethylene, chloroform and methylene chloride.

Installation of the steel pilings and grave-filled cells will be handled by Dravo Corporation.

Wagner Electric Corporation has elected three new executives. They are **J. C. Evans,** named controller; **E. G. Holtzman,** secretary-treasurer, and **J. P. Harbacek,** assistant secretary and assistant treasurer.

Evans held various sales and administrative positions after joining the Wagner company in 1935. He became assistant controller in 1952. As controller, he succeeds **F. F. Simon** who will remain with the company in a consulting capacity.

Holtzman joined Wagner in 1942 and since 1953 has been assistant secretary and assistant treasurer. As secretary-treasurer, he succeeds **J. D. Eby** who will remain with the company in a consulting capacity.

Harbacek has been with Wagner since 1922, and prior to his election as assistant secretary and assistant treasurer held the position of general credit manager.

A. O. Smith Corporation has plans for immediate construction of a new $350,000 administration building for its Electric Motor division at Dayton, Ohio. The building will be the opening-phase of a two-year expanson and re-equipment program expected to cost $3,250,000.

Other major portions of the expansion of the division's operations at nearby Tipp City, Ohio, include a manufacturing plant addition costing nearly $1 million to be started in 1957, and nearly $2 million in new machinery and equipment to be installed in 1956 and 1957.

Effect of the expansion will be a 50 percent increase in the Electric Motor Division's productive capacity.

Much of the new equipment will consist of a higher degree precision machinery designed to improve methods and to provide a higher quality product.

The expansion also will increase and unite present administrative, accounting, engineering and laboratory staffs under one roof. Plants and offices now are scattered in Tipp City and Dayton.

Carrier Corporation is conducting several schools to provide information for gas-utility sales engineers on large gas-powered air-conditioning systems. The first of these sessions was held in April at Carrier's Syracuse, N. Y., headquarters.

Purpose of the course is to equip men of the gas industry with the necessary techniques for selling and selecting the proper machine for applications where gas is the principal energy source.

Some 30 representatives from major gas utilities across the country were invited to attend the two-day workshop. Additional classes will be held during the next few months.

Borg-Warner Corporation now has **Paul A. Barkmeier,** formerly a vice president of Radio Corporation of America, in a newly-created position as its director of marketing services.

Barkmeier was with RCA from 1948 to 1955 in various executive capacities. In 1950 he became a vice president and was

For more date on advertised products, use Readers' Service Cards, last page.

50th Anniversary

Associated Business Publications

PETROLEUM REFINER is an active member of the Associated Business Publications which this year is celebrating its Golden Anniversary. We take this opportunity proudly to re-affirm our belief in the high publishing principles for which the Association stands and to assure our readers that we will ever "consider, first, the interests of the subscriber."

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Code of Ethics **- - -**The publisher of a business paper should dedicate his best efforts to the cause of business and social service, and to this end each member of the Associated Business Publications pledges himself:

1. To consider, first, the interests of the subscriber.

2. To subscribe to and work for truth and honesty in all departments.

3. To endeavor to be a leader of thought in his editorial columns, and to make his criticisms constructive.

4. To encourage all constructive efforts to improve the standards and quality of advertising.

5. To avoid unfair competition.

6. To determine what is the highest and largest function of the field which he serves, and then to strive in every legitimate way to promote that function.

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Suppliers . . .

appointed general manager of the RCA Victor Record division. Three years later, he was named vice president and director of distribution for all products.

In 1954 he became president of RCA Estate Appliance Corporation, which was later merged with RCA and reorganized as a division. Following this, he became vice president and the division's general manager, his last post with the corporation.

Prior to his RCA service, Barkmeier was controller of the Retail division of Marshall Field & Company for five years and held various merchandising and financial positions with Montgomery Ward & Company for 12 years.

H. K. Porter Company, Inc., has appointed **Charles L. Holbert** as executive vice president.

Holbert, who will be operating head of the company, succeeds **Clarence R. Dobson** who has retired. Dobson, who joined Porter in 1946, will serve as a consultant.

Holbert joined the company early this year as a vice president. Previously, he was vice president of Southern Pacific Milling Company, Ventura, Calif. Before that he was vice president and general manager of Johnston Pump Company.

A. O. Smith Corporation has appointed **Ben C. Heald** and **J. D. Kelly** as district managers for its Tubular Products division at Dallas and New Orleans.

The Dallas area includes the territory between Fort Worth, Dallas, northern Louisiana and southern Arkansas. The New Orleans area covers the coastal areas of Louisiana, Mississippi and Alabama.

Both men also act as sales representatives for A. O. Smith's Process Equipment section.

The Timken Roller Bearing Company has appointed **James Freese** as general production manager of all its plants.

Freese started with the Timken Company in 1929 as a production clerk. In 1937 he was promoted to assistant production manager of the Steel and Tube division, and in 1942 to the position of manager of production of the Steel and Tube division.

In 1953 Mr. Freese was named assistant general production manager of all plants, which post he held until his recent appointment as general production manager. He succeeds **James Reid,** retired.

Succeeding Freese as assistant general manager of production is **Charles L. Richey** who started as an inspector with the Timken Company in 1934. Richey was successively an assistant foreman, a scheduler expediter, assistant to the production manager and production manager of the Canton Bearing division, which post he held until his appointment as assistant general production manager of all Timken plants.

Maintenance Engineering Corporation has made three major promotions in its Engineering, Chemical and Sales divisions.

Bert I. Thorngren was given charge of the Chemical division; **Wilton H. Lev-**

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HIGH PRESSURE
GLASSES
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All sizes to fit your gages and valves
MAGNIFYING RED LINE
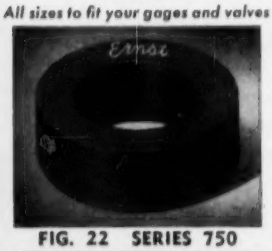
FIG. 22 SERIES 750
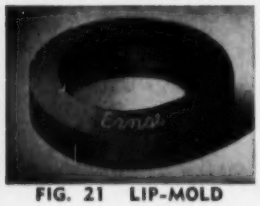
FIG. 21 LIP-MOLD
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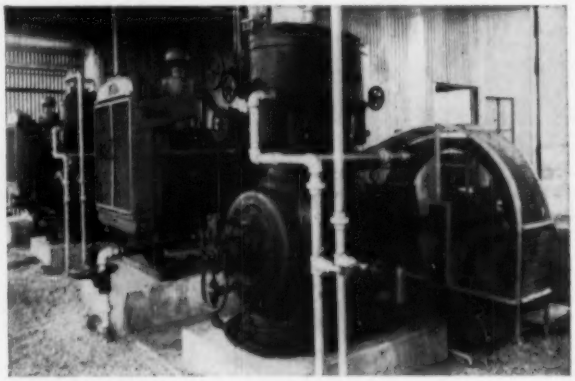
How to Cool 5,000,000 cu. ft. of Natural gas most economically

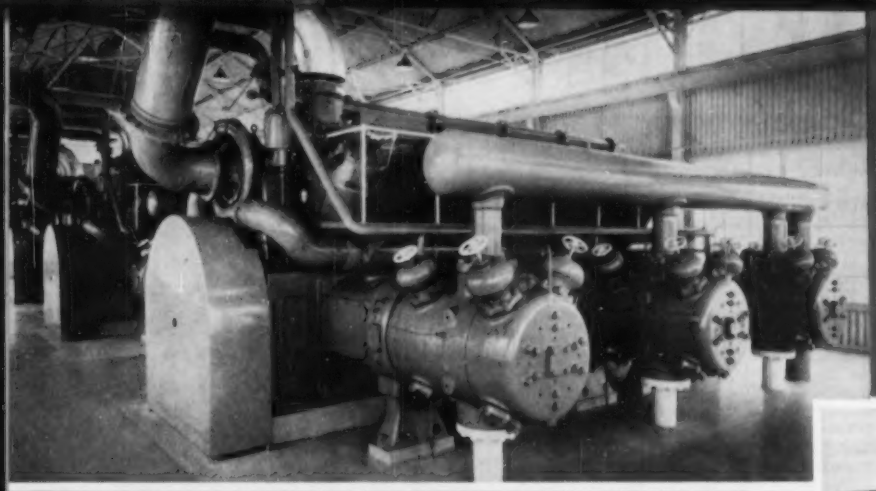


Woodward & Company are doing it at their plant near Washington, Oklahoma, with two Frick refrigerating machines driven by natural gas engines of 90 horsepower. These Frick compressors, which handle ammonia, are of size 9" by 9", and run at 400 r.p.m.

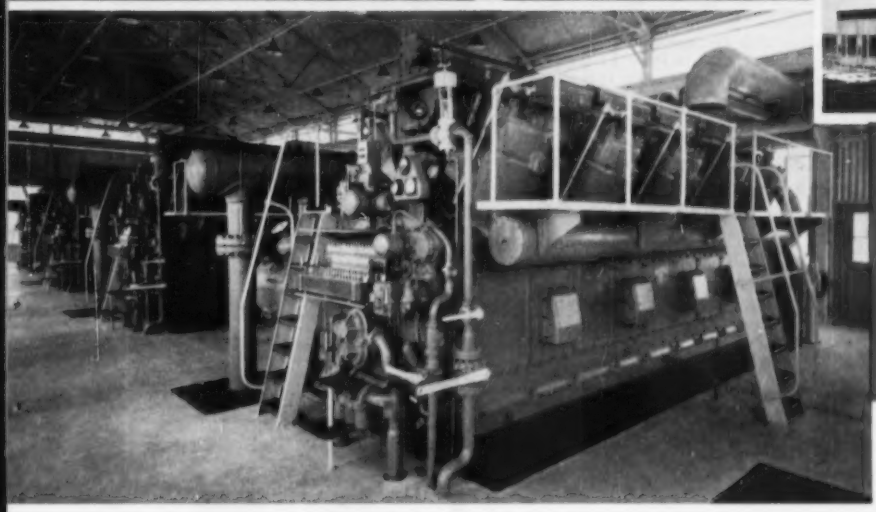
Propane and gasoline are recovered from the natural gas stream. A Frick condenser is used after the propane has been fractionated. The cooling equipment was installed by the Kay Engineering Company, Frick Distributors in Oklahoma City.

Whether you need cooling equipment for air conditioning, process work, ice making, quick freezing or other refrigerating purposes, you get the utmost economy and reliability when you insist upon Frick equipment. Write today for literature and estimates on the cooling work you wish to do.

DEPENDABLE REFRIGERATION SINCE 1882
FRICK CO.
WAYNESBORO, PENNA. U.S.A.



These installation photos show the new Cooper-Bessemer GMVA compressors which are identical in both the Keyes, Oklahoma and Springfield, Colorado transmission stations of the Colorado Interstate Gas Company. Below are exterior views of the compact Keyes (left) and Springfield (right) stations.



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The latest for Colorado Interstate Gas . . .

COOPER-BESSEMER GMVA's

for new highs in compressor performance

● Two important transmission stations of the Colorado Interstate Gas Company have installed new Cooper-Bessemer GMVA compressors with centrifugal blowers.

Both the Springfield, Colorado and Keyes, Oklahoma stations are equipped with four of these big, modern 10-cylinder GMVA's rated 1350 hp at 300 rpm. The GMVA compressor is an *even better, smoother operating* unit than the well-known GMV it replaces.

With the GMVA, there's a 10% reduction in fuel consumption, good air ratio to all loads, higher horsepower ratings with no space increase, operation on a variety of fuels, ample working space around power cylinders . . . and many other advantages that add up to increased compressor operating efficiency and reduced maintenance demands in the 540-1350 horsepower range.

For further information on the dependable and economical GMVA, drop in, or write to any of the conveniently located offices listed below. You'll be especially interested in Cooper-Bessemer's new, complete GMVA Catalog No. 75. Write for your copy today.

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Suppliers . . .

erett, of the Engineering division, and **Edward B. Haldeman**, of sales. All three were made vice presidents.

Thorngren started in the company's Chemical division in 1934, after four years with one of the larger oil companies. He is a registered professional engineer in Texas.

Leverett has been with Maintenance Engineering since 1935, having started in the Service department. He later concentrated on sales, and was made superintendent of shop operations. Since World War II, he has been in charge of Mason Neilan and A. O. Smith product sales for Maintenance. He also is registered as a professional engineer in Texas.

Haldeman became the company's representative for Lukens Steel Company products, coming to it from Lukens Steel. He has been engaged in the design, engineering and sales of plates and heads for high-pressure refinery vessels 20 years.

The Timken Roller Bearing Company has appointed three new district managers for its Steel and Tube division.

R. P. Donnell, formerly district manager at Cleveland, was transferred to New York as head of the district there. He started with the company in 1939 as a metallurgical service engineer, and has been manager of the Cleveland district since 1943.

Named to succeed Donnell at Cleveland was **Sherman R. Lyle**, formerly district manager at Buffalo. Lyle joined the company's sales force in 1946 and became manager of the Buffalo district in 1951.

Ross Hershey, who was a sales engineer at Detroit, was given charge of the Buffalo district. He has been with the company since 1940.

Roots-Connersville Blower, Division of Dresser Industries, Inc., is establishing a Pittsburgh sales office. Named to head the office there was **Edward N. Bonnett**, who will take over responsibility for organizing and managing a sales territory including western Pennsylvania and northern West Virginia.

Bonnett was assistant sales manager for The Stacy Brothers Gas Construction Company in Cincinnati, before joining Roots-Connersville in 1955. He completed a training program for sales engineers at the company's main plant and offices in Connersville, Ind., worked in the Cleveland, Detroit and Chicago offices, and for the past few months has been assigned to the Pittsburgh area.

Koppers Company, Inc., has established a Transportation Research and Development section. The new unit is believed to be the first formally organized unit of its kind in U. S. industry.

This section has been created primarily for the purpose of studying and developing solutions to complex transportation problems. This will include the study of transportation economics as it relates to plants and warehouses and their locations; the effects of freight equalization as compared with other means of allocating transportation expense; and the development of new distribution practices and management techniques.

Other related transportation subjects to be considered by this section are new packing and shipping methods and materials, development and use of new equipment, and other long-range studies of the

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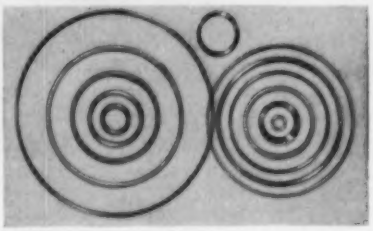
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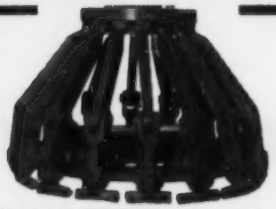
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for handling greases and other viscous fluids.
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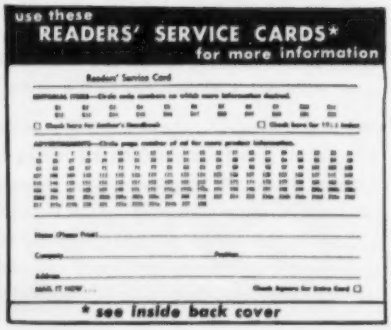

* see inside back cover

The new 12-acre plant of W-K-M Manufacturing Company, Inc., at Missouri City, Texas, is designed to permit three distinct product production facilities to function under one roof, the manufacturing plant alone covering almost 11 acres at ground level. Offices occupy 1200 square feet on the second floor of the steel frame building; offices, engineering space, reception and conference rooms occupy the remaining 48,000 square feet of floor space of the lower floor. The plant has a 2250-ton air conditioning system which converts to winter time heating.

impact of transportation on the overall efficiency of other operations in the company.

William C. Brittain, formerly with the Department of Defense in Washington, D. C., as a logistician and management engineer, has been named manager of the new section. He was instrumental in developing plans and legislation for coordinating the logistics activities of the various branches of the armed services to implement their unification under the Secretary of Defense.

For several years Brittain was with the Munitions Board of the Office of the Secretary of Defense. Subsequently, he became associated with the Deputy Chief of Staff of Logistics, Army Headquarters.

In addition to Brittain, the staff of the new section will consist of **Walter J. Keneski**, transportation analyst; **James A. Jordan**, management analyst, and **John G. Brodie**, assistant transportation analyst.

W-K-M Manufacturing Company is being reorganized to include operations formerly carried on by two other companies. Its reorganization comes with the opening of its new 12-acre plant on a 75-acre site at Missouri City, a few miles southwest of Houston.

J. S. Downs

It will be a consolidation of W-K-M Manufacturing Company, Houston, a subsidiary of ACF Industries, Inc., manufacturer of gate valves for oil production and pipe line installation; The Key Company, East St. Louis, manufacturer of return bends and fittings for oil refining and chemical processing; and the ACF Valve Division, Detroit, producer of lubricated plug valves for all industrial pipe line uses.

All activities of the three concerns will be conducted in the new plant on Highway 90-A and the main line of the Southern Pacific system. This plant has been designed so that each will function as a distinct manufacturing opration with individual production lines for each product.

Machinery from the former W-K-M plant in Houston, from the Key plant in East St. Louis and the ACF Detroit plant is being set up along with new equipment necessary for the expansion involved in the consolidated operation.

J. S. Downs, president of W-K-M Manufacturing Company, will continue to head the expanded organization. Management and other key personnel from both East St. Louis and from Detroit are being transferred to Houston so all standards of operation can be maintained.

The new organization is to be known as W-K-M Manufacturing Company, Inc., a subsidiary of ACF Industries, Inc.

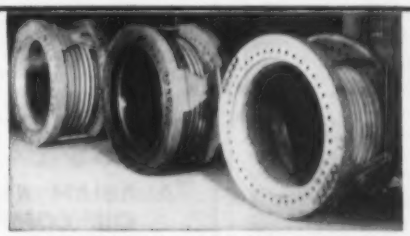
Suppliers . . .

Chiksan Company has appointed three new salesmen for its Western region.

Two of the men, **Edwin P. Illsley** and **John E. Burkett**, will operate out of the company's home office at Brea, Calif., serving the southern part of the state. **Joseph P. Beyer** will headquarter at the Oakland office which serves northern California.

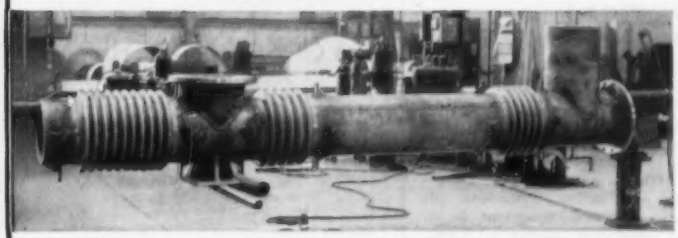
Burkett joined Chiksan after selling his interest in a Newport, Calif., firm which manufactures diving equipment. Illsley has been Chiksan production-control supervisor since 1952.

ADSCO



Three 48" Hinge-Type Corruflex Expansion Joints

ENGINEERING BACKS UP EVERY CORRUFLEX PACKLESS EXPANSION JOINT

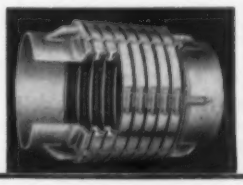


Complex stainless steel assembly of piping and joints absorbing four different motions

Regardless of size or degree of complexity of the joint involved, ADSCO applies its vast engineering experience to every piping problem presented to it. The help ADSCO provides not only makes the customer's piping react the way it should but also saves money in both installation and maintenance costs. Next time consult ADSCO, a leader in the development of maintenance-free packless expansion joints.

• *Write for Bulletin 35-51.*

Basic Corruflex Joint with Equalizing Rings



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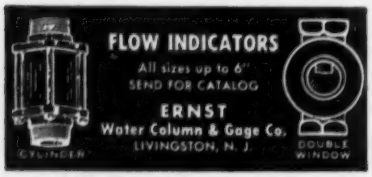
For more data on advertised products, use Readers' Service Cards, last page.

PETROLEUM REFINER Classified Ads

Petroleum Refiner New Classified Rates

RATES: Regular Classified (undisplayed) set in this size type: 12 cents per word. Minimum charge, $3. Blind box address in our care counts six words. Replies forwarded without charge. Situation wanted ads, 6 cents per word. Display ads, set in suitably larger type with ruled border, $12 per column inch; situations wanted display ads, $6 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

FOR SALE



New Fractionating Tower

One (1) new fractionating tower, 5'0" I.D. x 89'6" overall height x 1¼" plate. Thirty-four (34) bubble trays, ten (10) 18" - 300# manways. Stress relieved and built in accordance with API-ASME Code for 350 PSI working pressure. Located Wichita, Kansas.

Rock Island Oil & Refining Co., Inc.
321 West Douglas Avenue
Wichita, Kansas

Save on Your INDUSTRIAL TRACK

FOSTER QUALITY — FULLY GUARANTEED

RELAYING RAILS

Handle more cars better—cost less to install and maintain. Foster stocks all Rail Sections 12# thru 175#, Switch Material and Track Accessories.

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WANTED TO BUY

• PETROLEUM REFINER Magazine back issues (also forerunner: Refiner) Wanted to buy for cash. P. R. Ashley, 27 E. 21 St., New York City (10), New York.

HELP WANTED

ENGINEERS

Houston refinery has openings for Chemical and Petroleum Engineers with refinery experience.

Send complete resume to
P. O. Box 5008
HARRISBURG STATION
Houston 12, Texas

AREA ENGINEERS

Several graduate engineers with minimum 5 years' experience supervising maintenance engineering functions in oil refining or producing facilities, power plants, heavy industrial installations, manufacturing plants, or related operations. To establish technical supervision, procedures, maintenance operations and schedule routine and special work for major oil producing and refining operation with all supporting facilities; i.e., housing, feeding, recreation, etc.

Salary commensurate with background and experience. Write giving full particulars regarding personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 65

ARABIAN AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

Plant Equipment Inspectors

Graduate engineers with minimum 5 years' experience in design or inspection of petroleum processing plants and equipment. Major part of experience must have been in inspection work entailing general knowledge of all facilities. Develop inspection methods, supervise and conduct inspections and advise operations on codes and equipment limitations in a major oil installation located in Saudi Arabia.

Write giving full particulars regarding personal history and work experience. Please include your telephone number.

Recruiting Supervisor, Box 91

ARABIAN AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

POSITIONS WANTED

Refinery Engineer

Mech-Chem: Registered prof. engineer; presently overseas, age 41, 14 years with majors and independents in Britain, Canada, and South America. Wide experience, design, maintenance, construction, estimates and supervisory; 5 years industrial engineering machine and metal trades shops. Require responsible administrative position, project engineer or refinery engineer; domestic or overseas; available interview in U. S. May-June. Write Waite, 4233 Irving Avenue, Dallas 19, Texas.

HELP WANTED

PROCESS ENGINEER

"Experienced Engineers for process design with well established manufacturer, Mid-continent area. Challenging work with excellent opportunity for advancement. All replies will be kept in strictest confidence." Box 231-R, PETROLEUM REFINER, Houston, Texas.

SAFETY ENGINEER

For modern, independent oil refinery located near St. Paul, Minnesota. He will report directly to Plant Manager and be responsible for establishing and directing the safety policies and procedures for the operation and maintenance of the refinery, including a sound safety program, the procurement and maintenance of safety and fire fighting equipment, and coordination of plant design and safety.

A Bachelor of Science degree in Mechanical or Civil Engineering or equal with at least three years experience in oil refinery safety work required.

Furnish complete resume of experience and education, including salary requirements. All replies confidential. Write or apply in person:

GREAT NORTHERN OIL COMPANY
Pine Bend Refinery
P. O. Box 3596
ST. PAUL 1, MINNESOTA

Use
THE READER'S SERVICE CARD
For Information Concerning New Equipment and Manufacturers' Literature.

MECHANICAL ENGINEER

Graduate Mechanical Engineer with minimum of three years experience in oil refinery engineering. Must be capable of performing general refinery engineering work and aid in development of design specifications for refinery processing equipment.

Duties will be closely integrated with operations of new independent refinery which includes crude distillation, catalytic cracking, polymerization, coking and utilities.

Send complete résumé of education and experience, including salary requirements. All replies confidential.

GREAT NORTHERN OIL COMPANY
P.O. Box 3596
Saint Paul 1, Minnesota

Free to PETROLEUM REFINER Subscribers

Write for free booklet on preparation of articles for PETROLEUM REFINER, the technical press generally, as well as papers for technical meetings.

Use Reader's Service green cards in the back of this issue. Write on the card "Free Author's Booklet," fill in name, address and mail. No charge, no obligation.

OVERSEAS OPPORTUNITIES

Affiliates of
STANDARD OIL COMPANY (New Jersey)

Located in
SOUTH AMERICA

Have staff positions now open for:

MAINTENANCE ENGINEERS:
Will plan, schedule and coordinate oil refinery maintenance and construction projects and/or provide technical assistance to refinery crafts.

PROJECT ENGINEERS:
Assignments may include project development, cost estimation, materials specifications, design and drafting, and construction follow-up.

PROCESS ENGINEERS:
Work assignments may involve process design and control, economic studies, and/or scheduling of refinery operating programs.

EQUIPMENT INSPECTION ENGINEERS:
Will inspect refinery equipment and request equipment renewals when necessary due to corrosion or failure under safety codes.

Engineering degree and minimum of two years experience in oil refinery or allied chemical industry required.

Liberal salaries, benefit plans, and vacation policy.

WRITE

Giving complete address, age, marital status, education and details of previous experience. Box 308L, Radio City Station, New York 19, N. Y.

DU PONT
offers
PROCESS & EQUIPMENT DESIGN-ENGINEERS
a continuous flow of diversified, original assignments

New products with new problems are continually under development at DU PONT—it is our Design Engineers who find successful solutions for the commercial production of these products. Assignments are stimulating, different, difficult—not repetitive.

If you are a talented graduate engineer with 4 or more years design experience, DU PONT has opportunity for you. Consider this vital fact—our policy is promotion from within.

apply today to fill one of the immediate openings for

PROCESS AND EQUIPMENT DESIGNER-ENGINEER

Successful applicants will be capable, either now or with training, of translating research data into workable equipment and process designs. Will enjoy and have ability to work as a part of an engineering design team. Will be capable of handling field design problems which will involve working with shop or construction people. Experience in the design of processes or process equipment for chemical, petroleum, food processing and allied industries, knowledge of ASME Code For Unfired Pressure Vessels, and shop fabrication or piping design practice is helpful but not essential.

Applicants selected will make independent analysis, exercise individual judgment and coordinate the work of others while engineering and designing process equipment including tanks, vessels, distillation columns and machines. Equipment arrangements and piping work will also be included. Assignments are challenging and creative with full recognition for achievement.

Please send complete resume to:
Mr. T. J. Donovan
Engineering Department

E. I. du Pont de Nemours & Co., Inc.
Wilmington 98, Delaware

For more data on advertised products, use Readers' Service Cards, last page.

What's New in Equipment . . .

. . . and Manufacturers Literature

Interchangeable Electrodes

Allow a Variety of Titrations

Coulomatic Titrimeter This new instrument is said to eliminate standard solutions from the chemist's list of worries. Instead it generates ions of titrant electrically, right in the sample. There are no solutions to standardize and re-standardize, and the titration is carried out automatically from start to finish.

What is unique about this instrument, however, is its wide variety of interchangeable electrodes. These electrodes equip it to perform a number of difficult analyses for which there are no other satisfactory rapid methods.

Its biggest uses: speeding and simplifying determinations of mercaptans in petroleum products, halides in trade quantities. Less than 30 micrograms of mercaptan sulfur (0.0006 percent in a 5-milliliter gasoline sample) can be determined with 1 percent accuracy. Other determinations: arsenic, antimony, disulfide, cobalt, cyanide, ferrocyanide, nickel, thallium, thiocyanate, thiosulfate and vanadium; plus a variety of acid-base, redox and precipitation reactions.

The new titrimeter belongs to a class of instruments based on the following theory. When one Faraday (that is, 96,492 absolute coulombs) of electricity passes through an electrolyte, it causes a chemical change in one gram-equivalent weight of the material in solution. When all the sample has reacted, the analyst measures the quantity of electricity he has used, calculates the number of equivalents in the original sample. One coulomb is equal to one ampere of current flowing for one second. If the current doesn't change, the number of coulombs used in a titration is proportional to the time it takes to reach the end-point.

The coulomatic titrimeter uses this simple relation to make titration fast, easy and direct. It holds the current constant and records the titration time to the nearest 0.1 second. Time is proportional to concentration.

Because many laboratories are already equipped with Fisher titrimeters, the new instrument is designed to be used with the standard titrimeter control box. This detects the end-point and automatically stops the current and timer.

A wide variety of electrodes is also offered. These are of two kinds: generating and indicating. Example: in coulometric titration of mercaptans in gasoline, silver ions are generated by a silver-platinum electrode pair and the end point is indicated by a silver sulfide-glass pair. In halogen determinations, the end point is indicated by a silver-saturated calomel combination. Fisher Scientific Company.

Circle Item E1 on the Card

Steel Selection—"Comparison of Carbon and Alloy Steels for Pressure Vessels" in a new booklet which simplifies the selection of the proper steel for fabrication of equipment. In general the alloy steels exhibit higher allowable tensile strength in the —20 to 650 F. range; and that as temperature increases, allowable tensile strength decreases at various rates for the various steels. This behavior implies that among steels under consideration for pressure vessels, there is an optimum steel with respect to savings in either weight or cost, which are the two major advantages offered by alloy steels in the —20 to 950 F. range.

Of the nine graphs included in the booklet, the first plots allowable stress against temperature for the various carbon and alloy steels under discussion. The remaining eight graphs are paired according to maximum service temperatures in increments of 100 from 650 to 950 F. The first graph in each pair plots shell thickness and weight per square foot against PR values (psi times shell radius in inches). The second plots cost per square foot of shell against PR. Lukens Steel Company.

Circle Item E2 on the Card

Ethanolamine—Applications, chemical and physical properties, physiological properties, shipping specifications and handling and storage features of monoethanolamine, diethanolamine, and triethanolamine are described in this 54-page technical data book.

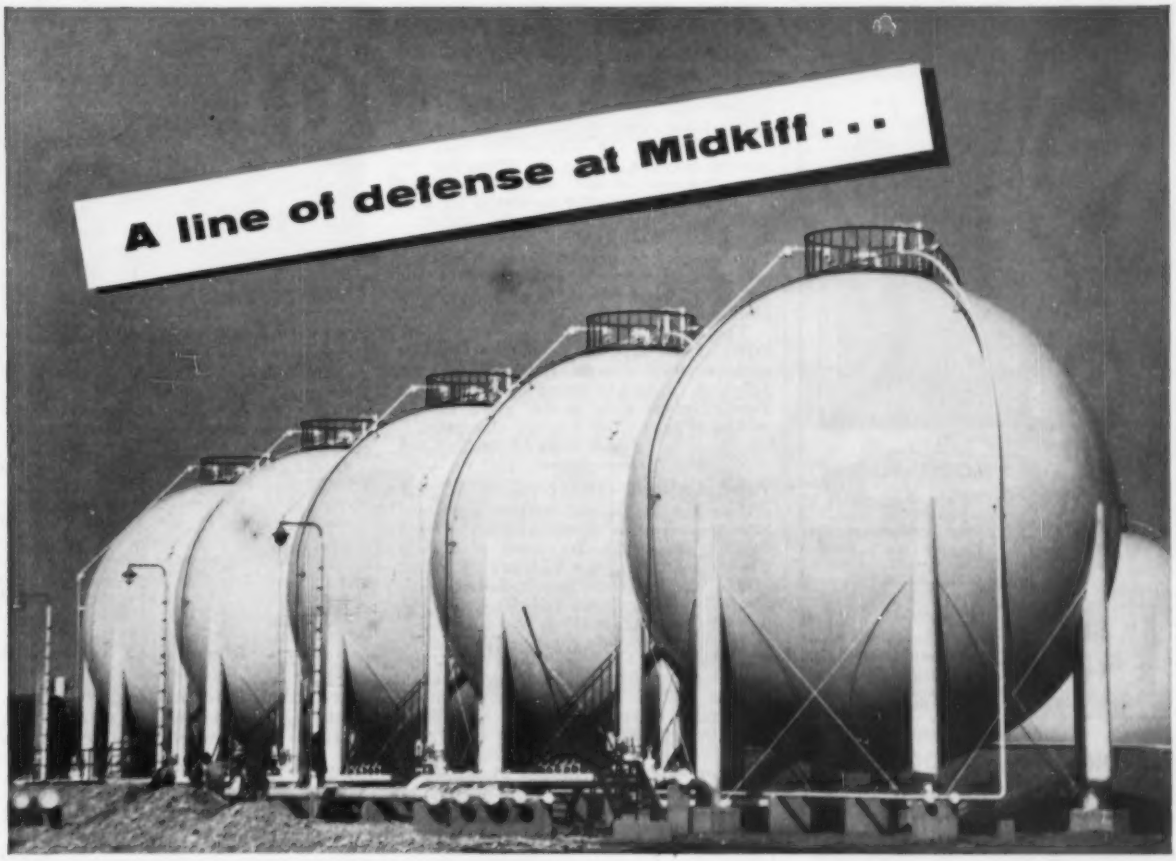
Complete analytical procedures to determine specific gravity, weight, boiling range, color and odor are given. Graphic illustrations include data pertinent to viscosities, vapor pressure, densities, freezing curves and other characteristics.

The ethanolamines are now products of Allied Chemical and Dye Corporation's Nitrogen division manufactured by an improved process which assures high quality and purity. They are characterized by their wide diversity of use in the chemical industry such as in gas purification, soaps and detergents, plastics and resins, pharmaceuticals, cosmetics and toiletries, paints and varnishes, glues and adhesives, and others. The ability of the ethanolamines to undergo reactions common to both the amines and the alcohols makes them important chemical building blocks. Allied Chemical and Dye Corporation, Nitrogen Division.

Circle Item E3 on the Card

Polyethylene Tape—Applications, specifications, cost data and advantages of Polyken anti-corrosion tapes are described in this 25-page catalog. Starting with the nature of corrosion and its control, the text leads into the advantages of wrapping with polyethylene tape. Cartoons and descriptive copy are used to emphasize these points.

The tape method of application to pipe is fully explained—preparation of surfaces,



Five Hortonspheres used for the storage of Butane

If *you* store or handle butane, you must take measures to prevent it from disappearing into the atmosphere. The 5,000-bbl. Hortonspheres® shown above, designed for 100 lbs. per sq. in. working pressure, are a reliable line of defense at the El Paso Natural Gas Company's Midkiff plant near Rankin, Texas. Vapor cannot escape as long as the internal pressure does not exceed the settings of the pressure relief valves.

Hortonspheres are built in capacities to 30,000 bbls. and for pressure to 217 lbs. per sq. in. in the smaller sizes. Write our nearest office for further information.

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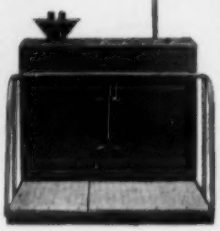
San Francisco • Seattle • Tulsa
Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

For more data on advertised products, use Readers' Service Cards, last page.

EMERGENCY
SAFETY SHOWERS
by
MORLAND

MODEL CO-100

Combination overhead shower and eye bubbler independently activated by aluminum platform treadles. Cabinet houses all piping. Steam or electric heat. Doors front or back.



MODEL SO-101

Safety Shower unit operated by platform grating. Non freezing type. (See inset, opposite.) Overhead light for night identification.

Other Morland Specialties:
Figure "8" Blinds, Temporary Strainers, Retractable Spray Nozzle Assemblies

write for complete details:

MORLAND ASSOCIATES
Office and Plant
63 South Avenue, Garwood, N. J.

New Equipment . . .

how they are coated, and inspection. Case histories of successful adaptations of this method are cited.

For instance, the Waynesboro, Ga., gas system, was the first in the country to be protected against soil corrosion by tape. This and other equally successful applications are all documented in the catalog.

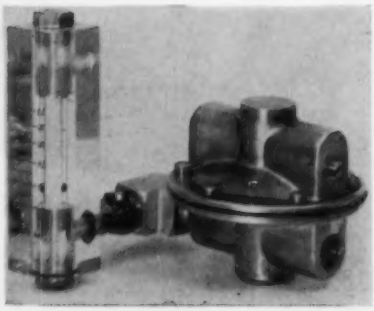
An additional section concerns specifications, surface preparations, taping and wrapping, inspection, repair and special wraps for welded pipe. Smaller, less common applications are also explained.

The closing section lists product properties of the tape by various components such as adhesive, backing, tensile strength, adhesion, dielectric strength, and so on. Pipe coverage data is also given for all widths of tape. The Kendall Company.

Circle Item E4 on the Card

Tube Caliper—High-precision internal dial caliper is designed to take fast, accurate measurements of tubes and tube holes in tube sheets. Constructed of highest quality materials, the caliper is spring loaded for greater accuracy, and is graduated in .001 inch. In addition to its use in tube maintenance work, the caliper can also be used in many other applications where extreme accuracy is necessary. The new Airetool caliper comes complete, ready for use, and can be obtained in calibration ranges of .400 to .800 inch, .800 to 1.200 inch, 1.200 to 1.600 inch and 1.600 to 2.000 inch. Price of the caliper is the same for all ranges. Airetool Manufacturing Company.

Circle Item E5 on the Card



Pressure Regulator—New differential pressure regulator incorporates a self-contained needle valve. The Model H-21F differential relay can be used for purging with air, water, or gas in services where actual measurement of the flow is unnecessary.

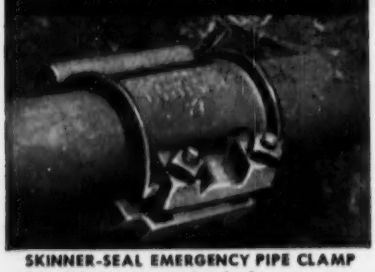
It can also be supplied in combination with a small flow rate indicator as a complete, compact, inexpensive purge meter package. Ranges from 0.2 to 2.0 scfh of air and 20 to 200 cc/min of water are available. Cost of the differential relay with integral needle valve is said to be about one-half the cost of standard purge assemblies now on the market. Conoflow Corporation.

Circle Item E6 on the Card

Electrically Heated Gages—For accurate gage readings of cold liquids—such as waxes—or to prevent gage breakage in cold weather, this electrically heated unit has been developed.

The electrical system also is valuable where there is need for very close control

TO REPAIR PIPE LEAKS—
QUICKLY, PERMANENTLY
ANY PRESSURE — ANY TEMPERATURE



SKINNER-SEAL EMERGENCY PIPE CLAMP
for pinhole or corrosion leaks.

SKINNER-SEAL PIPE LINE CLAMP for
long splits and bad corrosion leaks.

In stock—all supply stores

M. B. SKINNER COMPANY
SOUTH BEND 21, INDIANA, U. S. A.

LITHIUM METAL AND ALLOYS
LITHIUM HYDRIDE
LITHIUM HYDROXIDE
LITHIUM CARBONATE
LITHIUM CHLORIDE - BRINE - etc.

LITHIUM
MAYWOOD

Pioneers in Lithium
Since 1901

MAYWOOD CHEMICAL WORKS
MAYWOOD, NEW JERSEY
ESTABLISHED 1895

For more data on advertised products, use Readers' Service Cards, last page.

Prolong the Life of Vessel Liners by Armoring them with . . .

KLEMP **HEXTEEL** ▶

Hexteel is an armor and retainer for castable refractory monolithic linings used for cat crackers, reactors, regenerators, fractionators, heaters, strippers, risers, stacks, cyclones, ducts, breeching, furnaces and tanks.

and FLOORSTEEL ▶

Floorsteel is an armor and retainer for monolithic liners applicable to small diameters for pipe linings, heads, plenum chambers, sumps, stacks and furnaces.

Hexteel and Floorsteel carbon or stainless steel armors and retainers prolong the life of vessel liners by resisting abrasion and corrosion. Our engineering department is prepared to design your total lining requirements. Whatever the destination, we will deliver your Hexteel or Floorsteel world-wide in record time!

Emergency delivery of Klemp Hexteel via air transport

Write for your FREE copy of "Serving the Oil Industry for Over 40 Years."

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Chicago 38, Illinois

KLEMP METAL GRATING CORPORATION PR
6601 South Melvina Avenue, Chicago 38, Ill.
Gentlemen:
Kindly send me literature describing Hexteel and Floorsteel applications in the petroleum and chemical industries.
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WRITE FOR THE FACTS TODAY

Distributors are located in principal cities from coast to coast

Speedline STAINLESS STEEL FITTINGS
manufactured by **HORACE T. POTTS COMPANY**
566 East Erie Avenue • Philadelphia 34, Pa.

How Metallizing saves money in refineries

cuts machine repair costs 80%—
cuts equipment "down-time"—
permits reduced spare parts stocks

Practically any worn machine part—repaired for only 15 or 20% of replacement cost—in minutes and hours, instead of days or weeks.

Pump shafts • Impeller journals • Motor shafts
Rotor blades • Packing areas • Pump plungers

The list of metallizing users in the Petroleum field reads like a Blue Book of the industry. Here are just a few:

Cities Service Refining Co. — Ohio Oil Co.
Esso Standard Oil Co. — Phillips Petroleum Co.
Gulf Oil Co. — Socony-Vacuum Oil Co.
Imperial Oil Co. (Canada)

METCO
Metallizing Engineering Co., Inc.
1157 Prospect Ave., Westbury, L. I., New York • cable: METCO
In Great Britain: Telephone: EDGEWOOD 4-1300
METALLIZING EQUIPMENT COMPANY, LTD.—Chobham near Woking, England

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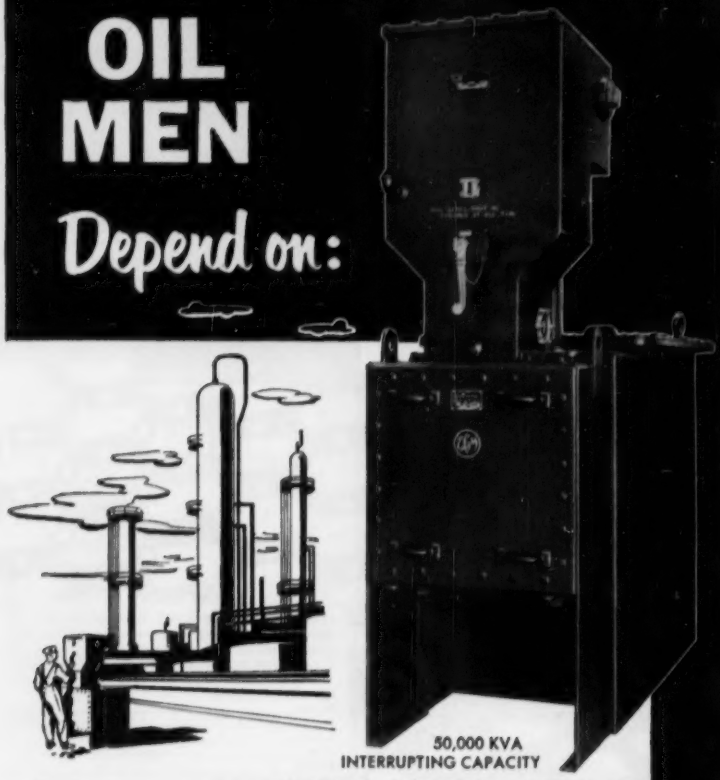
OIL MEN Depend on:



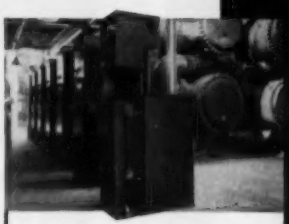
50,000 KVA
INTERRUPTING CAPACITY

EC&M 2200-5000 VOLT Motor Starters

These EC&M Div. 1 combination Starters for Class I, Group D locations give refinery engineers and construction and design companies top value. They require less floor space . . . line, motor and control leads are brought to conduit connection box for quick installation . . . and high interrupting capacity is inherent . . . 50,000 KVA, and no fuses required.

Oil disconnect switch (on top) may be locked open or closed . . . view windows on both sides show switch contacts. Rear oil-tank has potential transformer for 220-volt push button circuit. Type ZHS (50,000 KVA) Magnetic Contactor may be raised above oil for inspection without disconnecting any bolts or leads.

Before buying, investigate EC&M Combination Starters . . . they provide economy in installation, operation and maintenance . . . and they're complete in every respect.



ADVANTAGES of this Battery of EC&M Starters in a refinery.

1. Combination Starter with self-contained Oil Disconnect Switch
2. All internal wiring complete . . . leads brought to conduit box for easy connection to power and motor leads
3. Heavy duty contactor has alloy contacts
4. Slender design reduces floor space
5. Thermal-Magnetic Overload Relays give accurate motor protection . . . trip instantly on faults
6. Simple 3-wire time-delay UVP push button circuit

Write for descriptive Booklet 1062-VIII

THE ELECTRIC CONTROLLER & MFG. CO.
A Division of Square D Company
4498 LEE ROAD • CLEVELAND 28, OHIO

6722

New Equipment . . .

of temperatures in the gage glass. An electrical unit may be installed with a temperature control or thermoswitch positioned within the gage column to regulate the amount of heat output of the electrical element.

Gages are available in double-chamber reflex or external tube transparent gage models in various sizes and pressure groups. The jacketed cocks are available with connections screwed, for socket welds, or flanged, and may be furnished with or without ball checks. Any of the above units may be furnished in any material required to meet corrosive conditions.

Where explosion-proof construction is required, the electrically heated units can be adapted to the requirements of the Underwriters' Laboratory. All materials used conform to or exceed the requirements of A.I.S.I., A.S.T.M., and/or A.P.I.-A.S.M.E. A special heat-resistant silicone paint is used for the protection of the external finish.

The heating element in the gage is a Chromalox unit for 120 or 240 volt A.C., with wattage output to meet requirements. The valves are wrapped with resistance wiring with similar characteristics, and sealed in the metal jacket. Jerguson Gage and Valve Company.

Circle Item E7 on the Card

Drum Handling—New rotating drum handling attachment for fork-lift trucks permit easy placement and stacking of two drums horizontally or four drums vertically. The attachment's distinctive ability lies in the design of the rubber coated clamp arms. One arm is articulating and shaped with two concavities which fit the shape of a drum. The other is flat surfaced and tapered slightly so that upon release of clamping pressure the drums will roll into position.

This new attachment rotates through a 90 degree arc to permit picking up drums in the vertical position and stacking them horizontally at a height dictated by the capacities of the truck on which it is mounted. The 42-inch-long arms with a clamping range of from 17⅜ inches to 71⅜ inches, have a total capacity of 2000 pounds. The Yale & Towne Manufacturing Company.

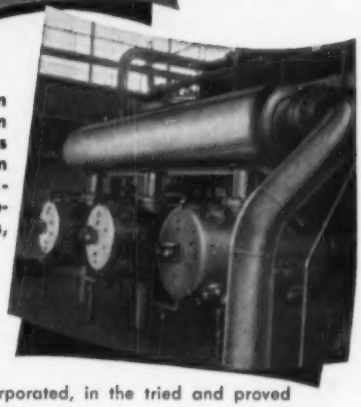
Circle Item E8 on the Card

Mineral Wool Insulation—Heat-loss data for establishing thickness-temperature requirements for mineral wool insulation is presented graphically in this convenient 8½ x 11-inch chart. Use of the graph eliminates laborious and repetitive calcu-

NOISE and PULSATION
engineered
right out of existence!

Our specialty is analyzing and correcting problems of:

(1) Intake and exhaust noises of air, steam and gases from compressors, blowers, jets, turbines, engines, etc.



(2) Piping pulsation and vibration caused by surges emanating from pumping equipment, pressure reduction operations, etc.

We have incorporated, in the tried and proved Burgess-Manning Snubber, the science of pulse and slug arresting that has saved industry many dollars in increased production, decreased maintenance, elimination of compensation claims and improved public and employee relations.

Burgess-Manning Snubbers are specially engineered to your problems and may be had to integrally include many plus features such as: air cleaning, or spark arresting, or water separating, or heat recovery.

Let us tell you how Burgess-Manning Snubbers will solve your problems of Noise and Pulsation.

Write for literature and free case history material

BURGESS-MANNING COMPANY

Sound Engineering 711 East Park Avenue, Libertyville, Illinois
Dallas, Texas

As SIMPLE and Dependable as the Pull of a MAGNET!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.

MAGNETROL
The Simplest, Most Versatile LIQUID LEVEL CONTROL Ever Devised!

Linked to liquid level by infallible magnetic force, Magnetrol is free from the limitations inherent in mechanical or electrical controls. With the actuating magnet rated at 98% of initial strength after 30 years, Magnetrol has *infinite operating life*, with practically no maintenance at all. There are no wearing parts to get out of order.

What's more, Magnetrol's simple operating principle permits easy, economical modification of standard units to meet *any* pressure, temperature or corrosion requirements. That's why there's practically no limit to Magnetrol's use. It's also why "specials" are likely to be standard with us. Magnetrol units control level changes from .0025-in. to 150-ft. —with single or multi-stage switching.

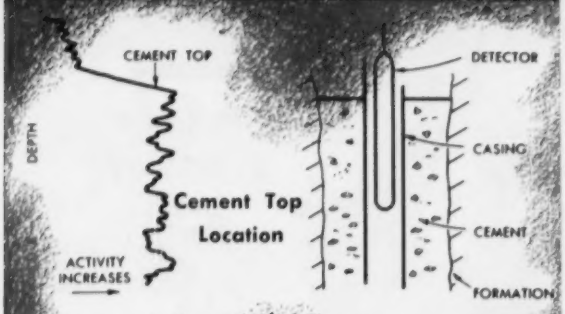
MAGNETROL, Inc.

● SEND COUPON FOR DETAILS

MAGNETROL, Inc. 2112 S. Marshall Blvd., Chicago 23, Illinois
Please send me catalog data and full information on Magnetrol Liquid Level Controls.
Name_____
Company_____
Address_____
City_____ Zone_____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

BETTER RADIOISOTOPE SERVICE



another *Tracerlab* first . . .

TRACEOIDS and TRACESOLS for the PETROLEUM INDUSTRY

Now you can apply radioactive tracers to help solve your production problems. Tracerlab, leader in developing radioisotopes for industrial use . . . is prepared to furnish TraceSols (gases and soluble compounds) and TraceOids (a wide variety of materials with variable density and particle size), specially developed for use in exploration and drilling operations.

TraceOids and TraceSols are useful to the petroleum industry, for example, as tracers to evaluate and control water flooding of oil fields for secondary recovery operation; to test oil well casing cement for leaks; to tag drilling mud to determine the permeability of the formation being drilled; and for many other similar operations.

These short lived compounds can be shipped from our Houston Laboratory on short notice to points anywhere in the United States, Canada and Central America.

Tracerlab's wide experience in the use of radioisotopes in industry is your assurance that TraceOids and TraceSols will help you complete your field work quickly and accurately. For your copy of Tracerlab's catalog describing TraceSols and TraceOids in detail, write today.

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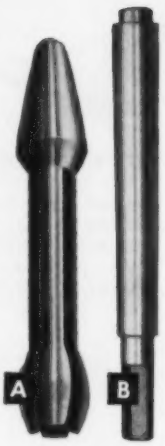
Wilson Tube Cutter

CUTS COSTS!

The Wilson Tube Cutter costs two to eight times less than competitive tools. You also get a tube cutter with eight exclusive features:

(1) It has fewer working parts. (2) It can cut non-ferrous tubes in under four seconds. (3) You can chuck it into your own air or electric drill. (4) It has a replaceable spacer collar to adjust for tube thickness. (5) The cutter bit retracts after withdrawal of the cutter. (6) You have a choice of round or taper shank in smaller sizes. (7) To operate, you insert the cutter in the tube, switch on the power, and press forward. (8) It takes the punishment of constant use.



A Tube Pilot guides tubes through baffles and far sheet when retubing.

B Tube Knockout tool for manual or mechanical use.

It makes good sense to buy the Wilson Tube Cutter and accessories. For some more suggestions that will cut your tube maintenance costs, write for Wilson comprehensive Tube Expander Catalog. For tube cleaners, send for Wilson Catalog 77.

Don't Forget!

For cleaner cleaning WILSON TUBE CLEANERS

For easy, accurate tube rolling WILSON TUBE EXPANDERS

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lations for determining outside surface temperature and surface heat loss for various thicknesses of mineral wool block insulation used with ⅜-inch-thick white mineral wool insulating-finishing cement. Thicknesses of block up to 4-inch; hot surface temperatures to 1700 F, and outside surface temperatures to 220 F are covered. Baldwin-Hill Company.

Circle Item E9 on the Card

Pendant Fixture—Flexible cushion fixture-hanger permits movement as much as 15 degrees from vertical. Explosion-proof and dust-tight, this hanger is designed to eliminate damage to fixture and stem assemblies while supporting loads up to 65 pounds. Action of a high-strength brass bellows is aided by a stainless steel cushioning spring, to permit movement. A set screw locks the threaded stem in place. Stem assembly is designed so that it will not turn or twist the wires or connections.

This new flexible cushion fixture-hanger meets NEC requirements for flexible support of pendant fixtures on rigid conduit stems longer than 12 inches. One complete assembly of Condulet and cushion fixture-hanger cover does the job. No bracing or separate flexible device is needed.

Factory-assembled fixture-hangers with junction Condulets are available in ½- and ¾-inch hub and fixture stem sizes. Also available are separate fixture-hangers which mount on any of the CPS Series Form 20 Condulets. These Condulets, when assembled with fixture-hangers, are approved for Class I, Groups C and D; Class II, Groups E, F, and G, and Class III. Crouse-Hinds Company.

Circle Item E10 on the Card

Piping Flexibility—Reduction in piping costs is the subject of this new 12-page brochure. The publication details the Kellogg "general analytical method of piping flexibility analysis," which represents one of the most comprehensive approaches devised for evaluating stresses, reactions and deflections in complex piping networks.

This analysis involves the development and solution of simultaneous equations for determining forces and moments in the

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Extra heavy metal sections, identical bolting for glands and seal plates are combined with selected materials of construction to provide that "extra margin" needed to extend use life in corrosive-erosive services.

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3. ***They are balanced—dynamically—radially—axially—eliminates—*** vibration that would cause damage to rings ... bushings ... bearings ... packing or mechanical shaft seals ... excessive radial and thrust loads on bearings.
Increases—availability for profitable operation.
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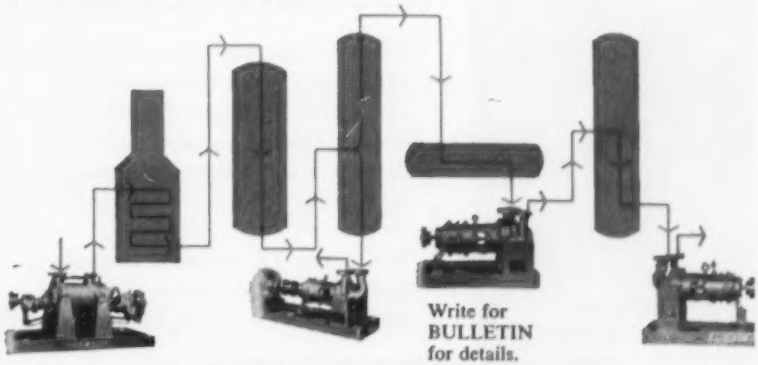
4. ***Positive lubrication of bearings***—oil rings pump oil up into bearing cap from where it must flow through—not around—the bearings back into the oil reservoir—contributes to trouble free operation ... longer bearing life ... low maintenance.

5. ***Labyrinth seal*** in each bearing cap ... no contact between shaft and seal ... keeps oil in and dirt out of bearings—prevents contamination of lube oil—contributes to trouble free operation—low maintenance.



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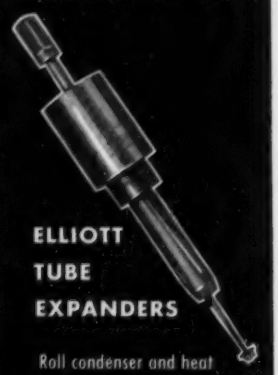
For more data on advertised products, use Readers' Service Cards, last page.

ELLIOTT EQUIPMENT ASSURES ACCURATE Tube Rolling!

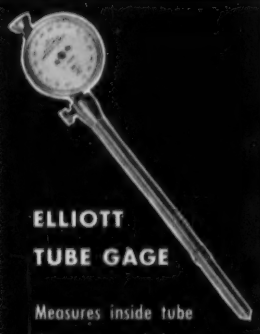


ELLIOTT TUBE EXPANDERS

Roll condenser and heat exchanger tubes quickly and accurately. Rotating, parallel self-feeding rolls insure good joints. For tubes ½ in. through 1½ in.

Table for data on torque control setting
Operating instructions
Time delay adjustment
Voltage Balance indicator dial
Torque Control setting
Voltage Balance switch
Power switch
Red light indicates power on
White light indicates tube is rolled
Motor selector switch
Motor cord
Remote signal light with 25-ft cord indicates when tube is rolled
Power cord

The control box is equipped with heavy non-skid rubber feet. These also protect it against water on the floor, etc.



ELLIOTT TUBE GAGE

Measures inside tube diameters on dial in thousandths of an inch. A quick guide for setting tube expanders for condenser and heat exchanger tubes. Three-point contact of hardened steel balls insures accurate measurements.

ELLIOTT ELECTRIC CONTROL

Assures tight, uniform tube joints everytime. It's a torque-limiting device that automatically balances outside voltage variables without the need of a separate voltage regulator.

Write for Descriptive Bulletin Y-40. Elliott Company, Lagonda Division, Springfield, Ohio.

ELLIOTT Company

Y6-2A

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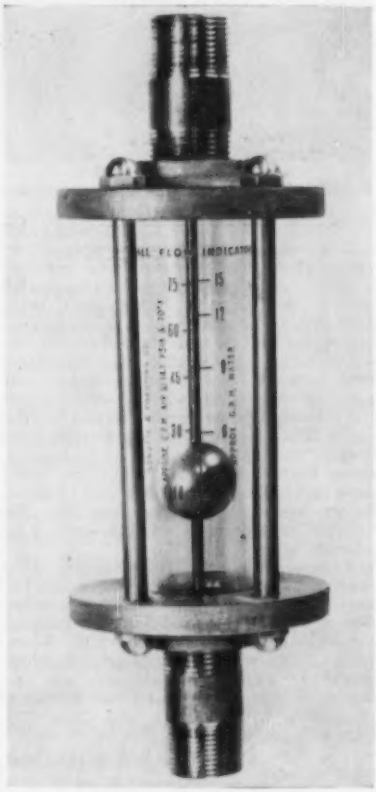
piping system. From these forces and moments, stresses and deflections are calculated.

Since the analyses are not based on approximations or "short-cut" calculations, it is possible to specify more closely to the theoretically perfect piping design, thereby avoiding excessive and costly margins of safety.

Described also are Kellogg's piping model test and its electronic computing facilities, used to solve those systems which cannot be solved "manually" with economy. By means of a scale model, the piping test permits simulation of the most intricate piping networks, and allows a direct reading of all the multiple forces and moments involved when the system's components are deflected.

An interesting feature of the booklet is the solution of a typical piping stress problem—a high temperature reheat system for a utility central station—by both the general analytical method and the model test. The M. W. Kellogg Company.

Circle Item E11 on the Card



Flow Indicator—New ball-type flow indicator with dual scale permits approximate measurements of water flow in gallons per minute or air flow in cubic feet per minute. The indicator uses a ball on a guide rod, installed in a tapered glass tube to indicate flow in a pipe line. When fluid, water or air, flows from the inlet at the bottom to the outlet at the top, it exerts force on the free moving ball causing it to rise in the tapered tube, higher as the rate of flow of the fluid increases. The position

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• Cut-Away View Showing Viking's Gear-Within-A-Gear Principle

The unique and unusually simple construction of Viking Pumps . . . with only two moving parts . . . assures you of long, easy-maintenance operation with all grit-free liquids.

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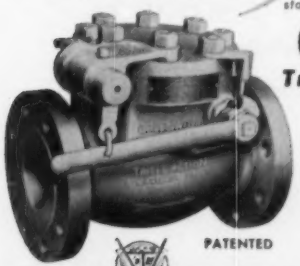
PLAY IT SAFE...install GREENWOOD Triple-Action Quick-Closing Valves on all lines and tanks handling volatile or combustible products. When fire breaks out ...VALVE CLOSES INSTANTLY (or valve may be remotely controlled in emergency)...confining and isolating products that cause the spreading and destructive action of fire. Write for details on these popular GREENWOOD Valves...they're the cheapest kind of fire insurance. Ask for Bulletin GV-11.

• GREENWOOD Triple-Action Quick-Closing Valves are available in 1", 2", 3", 4", 6" and 8" pipe sizes.

• Valves are regularly made of cast steel with stainless steel trim. Available for special services in monel, stainless steel or other alloys.



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Valves may be closed three ways:

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2 REMOTE MANUAL CABLE CONTROL.
3 APPLIED AIR PRESSURE OR AIR FAILURE.

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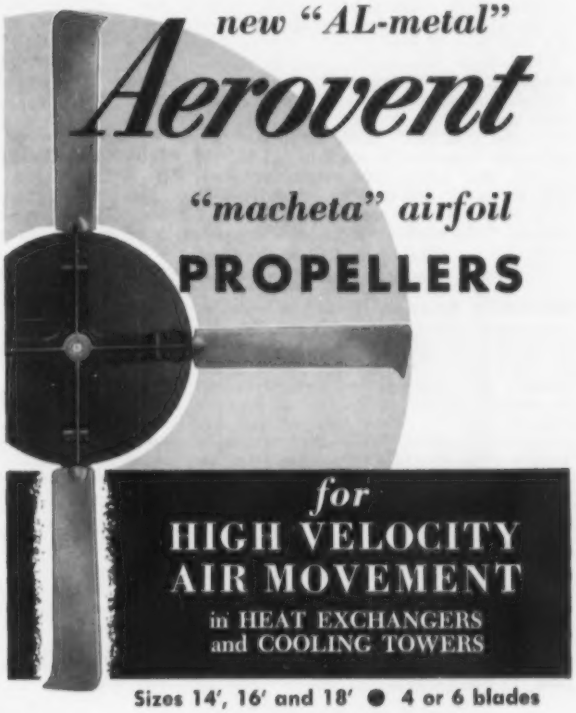

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HIGH VELOCITY AIR MOVEMENT
in HEAT EXCHANGERS and COOLING TOWERS

Sizes 14', 16' and 18' ● 4 or 6 blades

New Aerovent "AL-metal" Propellers for Cooling Towers, Heat Exchangers and special commercial and industrial applications, feature a new modification of the famous "Macheta" Airfoil Propeller – regarded for years as *industry's most efficient air-moving surface!*

Accurately-balanced, cast aluminum blades, designed to move *more* air with *lower* power consumption, are interchangeable with other blades in each assembly to speed and simplify installation and routine maintenance.

High-strength, cast steel alloy hubs, employing bolted construction, clamp keyed blade shanks securely to prevent loosening or turning; provide maximum resistance to vibration and operating stresses.

designed for DEPENDABLE *operation*

Endurance tests at *3 times* normal loading prove the ability of new Aerovent "AL-metal" Propellers to withstand punishment far in excess of operating requirements.

Other models for any type installation

Write today for free folder, engineering assistance and/or detailed performance data

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For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

of the ball in relation to the scale graduations gives an approximate indication of the fluid rate of flow.

This type flow indicator is recommended for use when flow is from one direction only—bottom to top in vertical pipe lines and when observation from any direction is desired. Made of bronze, the indicator is carried in stock in ¼, ½, ¾, 1, 1½, and 2-inch pipe connection sizes. The company also supplies other types of flow indicators for use under other conditions. Schutte and Koerting Company.

Circle Item E12 on the Card

Graphite Anodes—Design of cathodic protection systems using graphite anodes is simplified with chart and monograph in this six-page bulletin. Data showing resistance of horizontal and vertical anodes to earth and the conversion of rectifier outputs to yearly power costs will aid corrosion engineers in making economic studies of ground beds. Corrosion Control, Inc.

Circle Item E13 on the Card

CO_2 Analyzer—Chemically operated CO_2 analyzers and recorders are described in catalog 56-553-1. Included are illustrations of instrument operation and a typical boiler sampling installation. Application, distinguishing features, available models and standard charts also are covered. The Hayes Corporation.

Circle Item E14 on the Card

PVC Fittings—This comprehensive 12-page catalog shows characteristics, advantages and limitations of PVC pipe fittings and flanges. Operating pressures, temperatures, applications, price comparisons, fabrication advice, installation and supporting recommendations, dimensions and weights of unplasticized polyvinyl chloride fittings are listed. Grinnel Company, Inc.

Circle Item E15 on the Card

Ethylene Oxide—New 64-page booklet, "Ethers and Oxides" discusses the applications of thirty-two products including ethylene oxide and propylene oxide. It gives data on physical properties, solubilities, shipping, specifications and test methods, and constant boiling mixtures. Thirty-four physical property charts are also included. An important feature of the new book is a list of literature and patent references for individual compounds giving additional sources for more detailed information.

Ethers and oxides are solvents in the manufacture of surface coatings, cleaning compounds, photographic films, dyes and wood stains, and many other compounds. They are also used for concentrating organic acids and processing uranium ore. As intermediates, they are used in the manufacture of surface active agents, plasticizers, lubricants, pharmaceuticals, textile and rubber chemicals, adhesives, synthetic fibers, and resins and plastics. They are important insecticides, fumigants, reaction and heat transfer media, fuel blending agents, stabilizers, and corrosion inhibitors of the acid acceptor type. Carbide and Carbon Chemical Company.

Circle Item E16 on the Card

n-Hexanol—Uses for n-Hexanol are discussed in new technical bulletin. Data on its physical and physiological properties, specifications, shipping, resin solubilities and constant boiling mixtures are fully described.

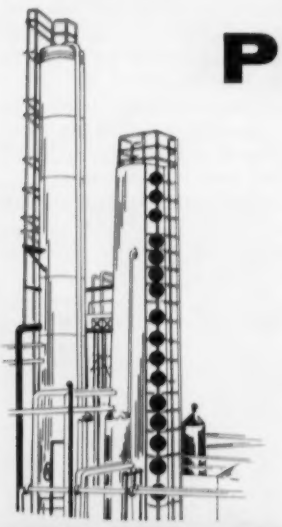
n-Hexanol is an intermediate for the manufacture of caproic acid, pharmaceuticals, detergents, textile and leather finishing agents, and plasticizers. It is used for introducing the normal hexyl group into numerous compounds and can be used as an entrainer in dehydrating hydrazine-water solutions.

It extracts hormones from aqueous solutions and is a solvent for special printing inks. Esters of n-hexanol are intermediates in the preparation of perfumes, insect repellent preparations, and special polymers that improve the properties of mineral oils used in transmission fluids. Carbide and Carbon Chemicals Company.

Circle Item E17 on the Card

Pneumatic-Operation Valves—For remote control of filling lines and use as emergency stop valves, where rapid operation is required, a new air-operated piston valve has been developed. This type of valve construction readily lends itself to pneumatic operation by a double-acting air cylinder, as there is no force required to hold the valve closed or open, and power is only required to move the piston from one position to another. Control of the valves is provided by small hand or solenoid operated valves or push buttons which can be placed away from the valve.

A typical installation is on a LPG bottling plant. One group of valves is fitted as emergency stop valves, and all these valves can be closed together from either



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For The Refining Industry

Posey's reputation for producing reliable welded steel plate structures dates back almost a half century. Coupled with modern engineering and production equipment and facilities, this experience has made Posey Iron a recognized source for Towers of all kinds and sizes.
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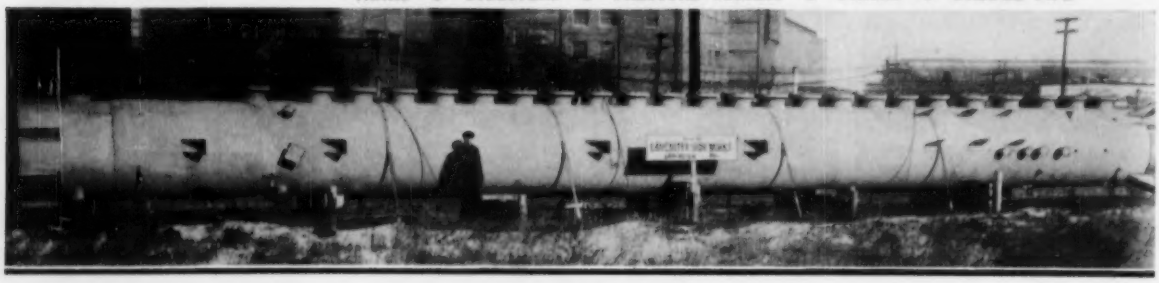

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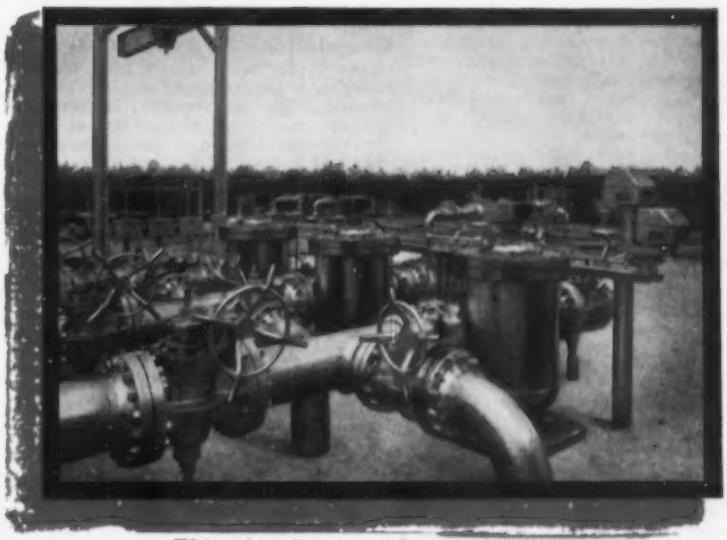
SAVES TANKAGE

MECO'S engineering service teamed with advanced equipment result in profitable use of three 10" Smith crude oil meters with the total throughput of all meters combined to print a single ticket for the total tender.



This pipe line to refinery installation includes 4", 6" and 10" meters.

with SMITH METERS

SAVE TANKAGE. This battery of Smith positive displacement meters has saved the large expenditure necessary for tankage by allowing incoming crude to flow directly to the stills.

HIGH % ACCURACY. Based on several years experience these meters have consistently maintained greater accuracy than obtained by the conventional tank gaging method.

LARGE VOLUME. 10" Smith meters in this installation have streamlined the handling of crude oil to this refinery, resulting in reduced evaporation losses and measurement costs.

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New Equipment . . .

of two operating positions remote from the valves. The other group of valves is being used on tank car filling lines.

These pneumatic-operation valves can be supplied in sizes from ½ inch to 6 inches in screwed or flanged construction with bodies of bronze, forged steel, cast carbon steel, and cast stainless steel; internal trim as desired. Klingerit Works-Richard Klinger, Ltd.

Circle Item E18 on the Card

Welding Data—Recommendations for arc welding various tubing steels are summarized on handy Technical Data Card 155A. In addition to indicating the proper electrodes to use, it provides information about preheating and postwelding heat treatments. Fabricators and others who have occasion to weld stainless steels and chromium molybdenum alloy steels in tubing and other forms will find this card valuable as a reference. Babcock and Wilcox Company, Tubular Products Division.

Circle Item E19 on the Card

Steel Hardness Data—The approximate relation between hardness by various testing systems and tensile strength of carbon and alloy steels is shown on Technical Data Card 183. The hardness systems covered are Brinell, Monotron, Vickers and Rockwell (B, C, and E scales). Babcock & Wilcox Company, Tubular Products Division.

Circle Item E20 on the Card

Platinum Catalyst—Timely bulletin outlines the general advantages and applications of platinum catalysts. The technical division of the book has detailed sections on the catalytic oxidation of ammonia, gas purification, measurement of impurities in gases, and supported platinum metal catalysts in chemical and petroleum processing. Some of the advantages listed for platinum metal catalysis are:

- Product purity
- Highest activity at low temperatures and pressures
- Easy to handle, non-pyrophoric
- Low cost per pound—the metal is recovered and reused.

Baker & Company, Inc.

Circle Item E21 on the Card

Coagulation—The selection of chemical treatment for water clarification is discussed in a new technical reprint, T-138. Important operating factors, theoretical chemical problems of coagulation, and physical consideration of the process are described in detail. A major portion is devoted to a discussion of proper selection of the coagulant and the various coagulants available. There is also a very useful table comparing the characteristics of these chemicals.

Of particular interest will be the Graver Jar Test Procedure used to determine the proper chemical to use. This test can either be used in the field or laboratory. The method of planning such a test is included as are several tables that indicate data on floc size, settling time and similar points. Graver Water Conditioning Company.

Circle Item E22 on the Card

Corrosion Data—Catalog 554 describes in words and pictures the facilities and workscope of a large midwestern fabricator—offering the latest techniques in the custom fabrication of steel and alloy plate.

Particularly useful for reference purposes are the comprehensive Corrosion Data Tables for various metals. They list the corrosive action of 200 different chemicals in various concentration forms on 16 different metals. These data have been developed in collaboration with research laboratories of the nation's largest metal producing companies. Nooter Corporation.

Circle Item E23 on the Card

Vapor Recovery—New general catalog P-7R contains latest information on tank equipment, gas control, safety devices, automatic controls, electronic remote liquid level gauging and pulse code telemetering systems. An outstanding feature of the catalog is the technical section which deals with tank storage conservation, vapor recovery and vapor balancing systems, supported by numerous tables and charts. Vapor Recovery Systems Company.

Circle Item E24 on the Card

Chemical Pump—Descriptive and engineering data covering the Eco rotary displacement pump for corrosive and hazardous fluids is contained in bulletin AC 56. Expressly designed for chemical handling, the pump is listed as available in several corrosion resistant alloy combinations with inert non-metallic impellers, seals and packing.

A general description of its design and applicability is followed by construction and performance data, complete operating

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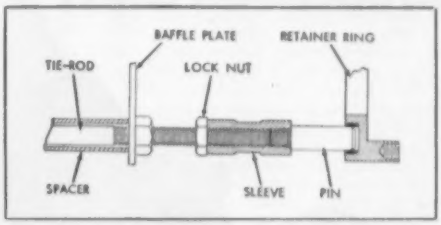
...and thereby hangs a tale

In recent years, Alberger has developed a simple, compact and rugged frame for "Karbate" Impervious Graphite tube bundles. "Karbate" Impervious Graphite is the material which has been so extraordinarily successful in handling concentrated acids and alkalis, salt solutions, halogens, and organic solvents. The patented Alberger frame completely protects the "Karbate" tubes during shipment, installation, maintenance, interchanging and replacement. You can even sling a rope around the middle, as shown in the illustration.

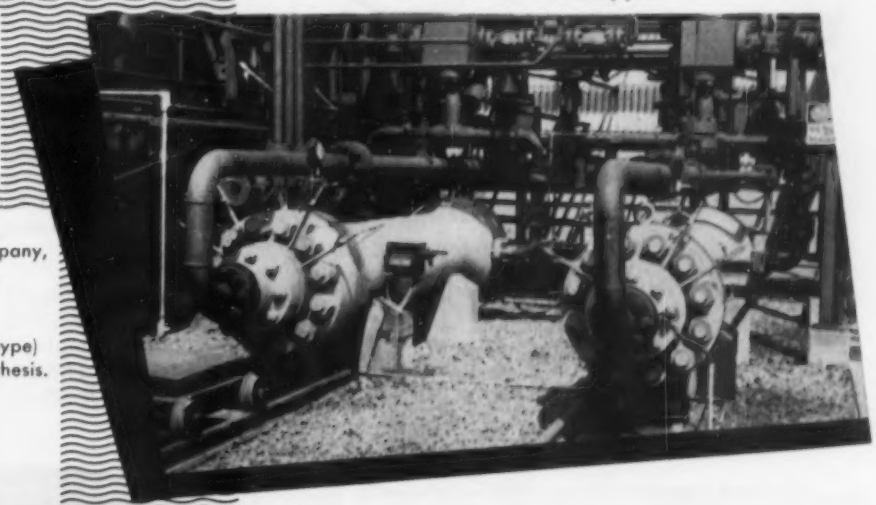
Alberger "Karbate" Heat Exchangers, cost slightly more than other "Karbate" exchangers, but they insure against breakage of the very expensive tube bundles. Thus, in the long run, Alberger "Karbate" Heat Exchangers are far less expensive, and they greatly reduce the labor costs involved in maintenance because they are so much easier to handle...Write for Bulletin K-212.



Stainless steel pins at end of tie rods slide in bushed clearance holes of floating tube sheet retainer ring.

ALBERGER HEATER DIVISION
ADSCO INDUSTRIES, INC.
20 MILBURN ST. BUFFALO 12, N. Y.

GHH H.P. Centrifugal Gas Circulators, Maulwurf-type



Spencer Chemical Company, Vicksburg, Mississippi, employs two GHH centrifugal gas circulators (Maulwurf-type) in their ammonia synthesis. These units have operated without trouble since February, 1954.

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Easy threading of ⅛" to 2" pipe or conduit

Snap size head you want into ratchet drive ring, from either side—it can't fall out. Dies reverse easily for close-to-wall threading. 00R and 0R, ⅛" to 1"; 111R and 11R, ⅛" to 1¼"; 12R, ⅛" to 2". Free carrier with sets. Conduit and special dies available. Real work-savers—at your Supply House!

RIDGID ***Bolt Threaders, too—No. 00R-B, ¼" to 1", National coarse and fine thread, efficient drop-head dies.***

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The Ridge Tool Company, Elyria, Ohio, U. S. A.

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Rely on Oakite for Cleaning Processing Towers:

Modern Oakite detergent-circulation methods eliminate needless expense for special work crews. Oakite "in-place" cleaning materials minimize dismantling . . . considerably reduce total offstream time.

Rely on Oakite for Cleaning Heat Exchangers:

Oakite offers specialized alkaline and acidic type compounds for removing numerous types of oil, carbon, lime scale and rust. Cleaning is done in place by safe, thorough chemical circulation methods.

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Oakite provides a complete selection of alkaline and solvent paint strippers. The specialized Oakite Hot Flow-On method permits storage tanks and towers to be stripped in a fraction of the time required by manual methods.

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New Equipment . . .

specifications on stock models, dimensional data, and specific information on component materials, drives and mounts.

Illustrations show various drive combinations that adapt this pump to conventional or special applications. ECO Engineering Company.

Circle Item E25 on the Card

Glass Heat Exchangers—A new 16-page design manual for Pyrex brand modular glass shell and tube heat exchangers is now available. The manual, edge-indexed for reading convenience, was prepared to help the potential purchaser choose the right module for his heat exchange system. Ten engineering drawings graphically illustrate how the Corning heat exchanger modules can be installed.

Engineering data for determining capacity requirements of the 50-square foot and 13½-square foot capacity heat exchanger systems include charts and information on fluid constants, friction losses, surface area calculations and thermal gradients. Corning Glass Works.

Circle Item E26 on the Card

Electric Heaters—Electric heaters and heating devices are covered in this catalog (Bulletin GEC-1005G), containing application index, calculating data, specifications, operating information, and list prices of standard G-E heaters and heating devices.

Included are immersion, strip, cartridge, tubular, fin, and railroad switch heaters; unit heaters, soldering irons, glue pots, soft-metal melting pots, oven equipment, and control. Process and application index shows methods of heating and type of heater recommended for various heating processes. General Electric Company.

Circle Item E27 on the Card

Fiberglas—"Materials For Industry" is a 12-page publication describing Fiberglas and Kaylo products for maintenance and supply. Illustrated by 15 photographs and 16 sketches are: Kaylo high temperature block and pipe insulations, Fiberglas industrial insulations, Fiberglas reinforced tapes and waterproof papers, Fiberglas insulated electrical apparatus, filters, built-up roofing and Fiberglas-reinforced plastic panels for sky and sidelights. Owens-Corning Fiberglas Corporation.

Circle Item E28 on the Card

Wrought Iron—A new folder describing wrought iron welding fittings and flanges in sizes ½ inch through 12 inches, discusses the physical properties of the material, and illustrates typical applications.

The demand for wrought iron pipe has grown substantially since World War II, chiefly because of its ability to resist corrosion and fatigue failure. Its resistance to corrodents is attributed to the purity of the base metal, freedom from segregated impurities, and embedded glass-like slag fibres. Wrought iron piping is employed in radiant heating, air conditioning and snow removal systems, and for other purposes where its special properties prove advantageous. Tube Turns.

Circle Item E29 on the Card

PVC Valves—This illustrated, six-page circular describes a new all-molded PVC valve. Luncor PVC valves overcome the disadvantages of other materials in handling a wide range of acids and alkalis and in resisting chemical attack and deterioration. A thorough series of tests and practical performance in all types of corrosive installations have proved their ruggedness and suitability for the rigorous demands of piping systems handling corrosives. Detailed information, including advantages, installation data and dimensions of valves and fittings, is contained in the new circular. Lunkenheimer Company.

Circle Item E30 on the Card

Mercury Switches—Complete information on pressure, temperature an drefrigeration controls featuring sealed mercury contact switches is presented in Catalog 856. Tilting and magnetic mercury switches are used in transformer relays, liquid level controls, combination pressure and low water controls, thermostats, boiler feed water pump controls and others. The Mercoid Corporation.

Circle Item E31 on the Card

Fire Pumps—Fire Pump Bulletin B-1500 contains complete selection charts listing over 120 different fire pumps approved by Underwriter's Laboratories, Inc. and by Factory Mutual Fire Insurance Companies. Pumps are also listed into groups according to types of drive. Drives available include electric motor, steam turbine, gasoline engine and diesel engine. Typical fire pump specifications and installation arrangements are features of this 36-page booklet. Peerless Pump division, Food Machinery and Chemical Corporation.

Circle Item E32 on the Card

Canned Motor Pumps—High temperature canned motor pumps are described and illustrated in Bulletin 1040. These new units are designed for leak-proof pumping of such fluids as Dowtherm, Arochlor, Para-Cymene and others at temperatures to 1000 F. Full details on performance, materials of construction, dimensions, power requirements and other specifications are included. Chempump Corporation.

Circle Item E33 on the Card

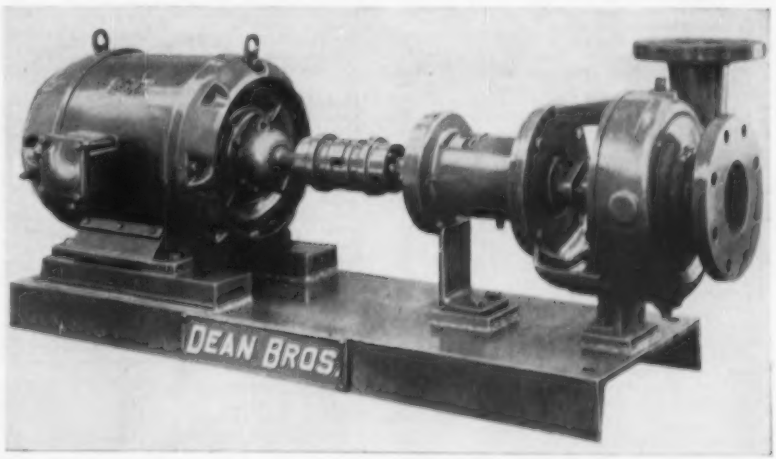
Air Compressor—A new portable rotary air compressor, capable of delivering 900 cfm at 100 psi, has been developed by Ingersoll-Rand. The Gyro-Flo 900, powered by a General Motors Series 110 diesel engine, uses a 24-volt battery and ether-capsule system to ensure starting at extremely low temperatures.

An outstanding feature is the oil injection cooling system. Cooled oil, from the radiator-type oil cooler located in front of the engine radiator, is injected directly into the air during compression. The oil performs three functions: it cools the air—it oil-seals the blades against air slippage—it lubricates the sliding blades. The oil then passes into a separator and is reused. Weights and dimensions are detailed in form 2313. Ingersoll-Rand Company.

Circle Item E34 on the Card

High Temperature Refractory—Two new castable refractories have been introduced. The first, Super Castable No. 32, is suitable for temperatures to 3000 F.; the second, Lite-Wate Castable No. 50-NISF, is a sulfur free product containing less than 1 percent iron content. Casting, airgun, or trowelling may be used to place either castable. Walsh Refractories Corporation.

Circle Item E35 on the Card



Vary in Size

Standardized Pumps Feature Only 3 Parts

General Service Pumps—Interchangeability of parts is featured in a new line of general service pumps. Only three parts—impeller, casing and back head cradle—vary with the size and capacity of a new line of seven standard centrifugal pumps for general service and chemical service. The new type "GS" series ranges in size from 1 inch x 2 inches to 3 inches x 4 inches. Pumping capacity extends to 600 GPM and total dynamic head to 275 feet. Pumping temperatures cover a range from minus 40 F. to plus 350 F. Type "GS" pumps are described in Circular 190 as an inexpensive quality line of standardized pumps for a wide range of applications where conditions do not necessarily require a more costly "engineered" pump. Dean Brothers Pumps Inc.

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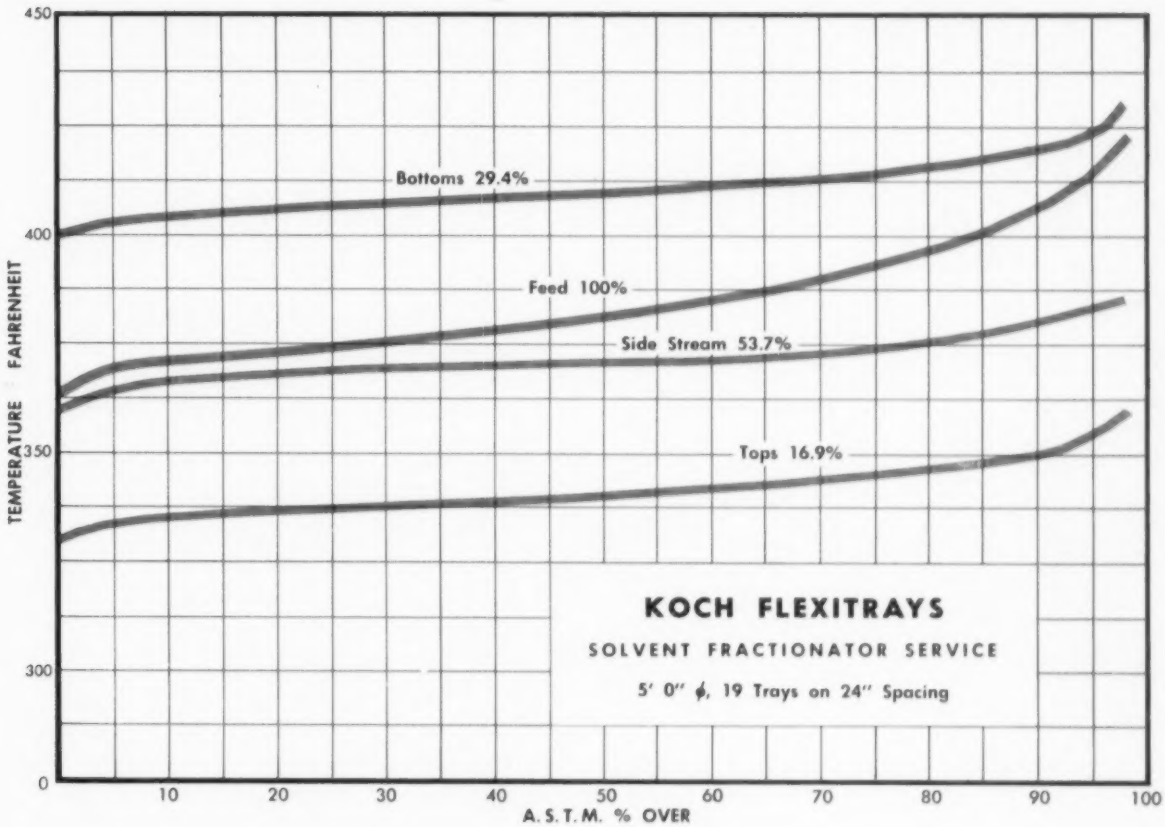

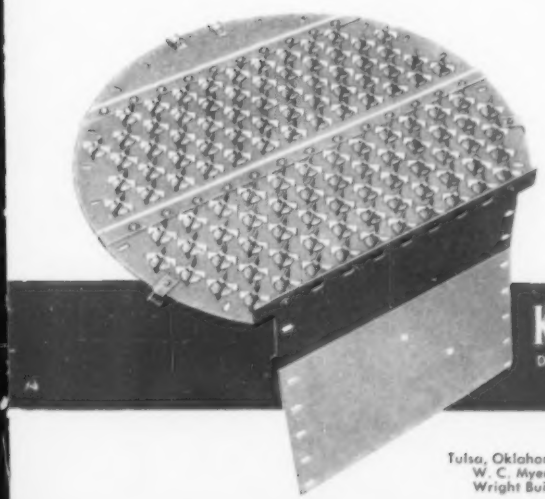

The above graph illustrates the clean separation of relatively short boiling range solvents. The required flexibility and high tray efficiency for such separations has always presented a challenge to tray designers.

Numerous repeat orders from large solvent producers indicate an eventual complete changeover from bell caps to Flexitrays for this exacting service.

Flexitray's adaptability to existing downcomers and supports makes such replacements highly economical. The performance records of the Koch Flexitray are outstanding. Wire, write, or phone us on its application to your problem.

KOCH ENGINEERING COMPANY, INC.

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501 Alcoa Building

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